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UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

STATUS

OF THE

MESOZOIC FLORAS OF THE UNITED STATES

SECOND PAPER

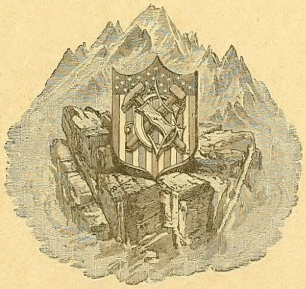
BY

LESTER F. WARD

WITH THE COLLABORATION OF

WILLIAM M. FONTAINE, ARTHUR BIBBINS, AND G. R. WIELAND

Part I.—TEXT



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LETTER OF TRANSMITTAL.

Department of the Interior,
United States Geological Survey,
Washington, D. C., May 31, 1904.

Sir: I transmit herewith the manuscript of a report entitled "Status of the Mesozoic Floras of the United States, Second Paper," by Lester F. Ward, with the collaboration of William M. Fontaine, Arthur Bibbins, and G. R. Wieland, and recommend its publication as a monograph.

Very respectfully,

C. W. Hayes,
Geologist in Charge of Geology.

Hon. Charles D. Walcott,
Director United States Geological Survey.

STATUS OF THE MESOZOIC FLORAS OF THE UNITED STATES.

SECOND PAPER.[a]

By Lester F. Ward and others.

PART I.

THE TRIASSIC FLORA (Continued).

As it will probably be many years before it will be possible to return to the subjects discussed in the first paper of this series in the Twentieth Annual Report, it seems advisable to publish at this time all the additional matter that has accumulated since that paper appeared. This consists of two rather important series of facts, one relating to the Trias of the Southwestern area, being the result of investigations in Arizona during the months of May and June, 1901; the other consisting of Professor Fontaine's report, giving descriptions and figures, on the plants collected in the Jurassic of Oregon in September, 1899. Both of these results were anticipated in the first paper (pp. 319–323, 374–377), but the brief notes there given would be very incomplete without the additional matter that is now available. A brief account will also be given of some additional specimens of Jurassic cycads from the Freezeout Hills of Wyoming, collected since the first lot was received and described in the first paper.

THE OLDER MESOZOIC OF ARIZONA.

The brief reconnaissance made by me from November 3 to 16, 1899, an account of which was given in the first paper (pp. 320–332), only sufficed to indicate in a general way the great interest that attaches to the region visited and the possibilities it possesses from both the

[a] The first paper appeared in Twentieth Ann. Rep. U. S. Geol. Survey, Pt. II, 1900, pp. 211–748, pls xxi–clxxix.

stratigraphical and the paleontological points of view. It was my intention at that time to improve the first opportunity that presented itself to conduct a much more extensive campaign into that region. I found the country so exceedingly dry in November that I imagined, and indeed was told by persons who live there, that spring would be a much more advantageous season for such a campaign. I therefore decided to make a somewhat exhaustive study of this region, with an appropriate outfit, in the months of May and June, 1901.

The discovery that I made on November 14, 1899, of fossil bones near Tanners Crossing of the Little Colorado (see first paper, pp. 322–323) seemed to make it one of the prime requisites of such an expedition that it be accompanied by a competent vertebrate paleontologist, well versed in the methods of collecting and preserving fossil bones. When the attention of Prof. H. F. Osborn was called to this subject he manifested a lively interest in it and offered to select a suitable person to accompany me for this purpose. The choice fell upon Mr. Barnum Brown, of the American Museum of Natural History, whose success as a collector of fossil vertebrates and as a field naturalist in general has secured for him wide recognition. The United States National Museum, being in need of a series of Triassic bones, assumed the responsibility for this part of the expedition. The rendezvous was at Holbrook, Ariz., on May 7, where an adequate outfit was procured and the expedition started on the 8th. The route followed was nearly the same as that pursued by me in 1899.

The object was to make as complete a study as possible of the geology and paleontology of the Little Colorado Valley, as it is in that valley, or at least in that drainage, that nearly all the older Mesozoic of this part of Arizona is to be found.

Certain signs of the occurrence of Triassic vertebrates made themselves known at different points along the route, but only as weathered out on the surface in such a manner that their original source could not be traced. But as soon as we reached the region of variegated marl buttes, some 5 or 6 miles above the Lees Ferry road, such bones began to be found and their position in the beds located. Nearly three weeks' careful investigation of the entire region in which such beds occur proved that the small group of buttes in which I first found the

bones was the richest in this respect, and the greater part of Mr. Brown's collection was made within a mile or more of the original locality.

It will of course be impossible for me to give any adequate account in this place of Mr. Brown's collection of Triassic bones. Suffice it to say that he made an extensive collection, consisting to a considerable extent of well-recognized bones, some of them entire, others capable of having the separated parts brought together, but others, of course, as in the case of Triassic bones the world over, more or less fragmentary. They represent chiefly the Belodont, *Heterodontosuchus ganei* Lucas, mentioned in the first paper, page 323, but teeth and other parts were found that probably belong to ancestral dinosaurs, while one very large scute belongs to the genus Labyrinthodon. The collection was shipped to the National Museum at Washington. It has been unpacked under the direction of Mr. F. A. Lucas, in whose hands it will doubtless be carefully worked up and the results duly published.[a]

I am very glad to be able to record the success of this expedition from the standpoint of vertebrate paleontology, because from the standpoint of fossil plants my anticipations were not realized. In a region which contains almost everywhere such an enormous quantity of silicified wood and which consists so largely of sedimentary and definitely stratified rocks it was reasonable to suppose that there would be found occasional beds at least in which impressions of the foliage, fruit, and flowers would be preserved. But the search was almost wholly without success, and the conclusion was reached that for one reason or another the conditions for the preservation of the parts of plants which are most essential in the determination of the flora were absent from this entire region.

The explanation of the absence of plant impressions of the more delicate kind is probably to be found mainly in the great abundance of gypsum that prevails throughout all these beds, which, as is well known, is almost fatal to the preservation of organic remains. But for it no doubt the vertebrate remains would be much more abundant and complete, and it is only the silicified wood that seems to escape its influence. This latter, however, is mainly deposited in beds of sand, coarse gravel, or conglomerate, which, in themselves, are unfavorable to plant impressions.

[a] A preliminary report was published by him in Science, N. S., Vol. XIV, September 6, 1901, p. 376.

The absence of plant impressions enabled me to devote more attention to geological considerations than would have been practicable had large collections of plants been made; and I regard the geological results as of sufficient importance to be introduced here somewhat fully. This chapter will therefore be divided into two parts, the first of which will deal with the stratigraphy and the second with the paleontology.

STRATIGRAPHICAL RELATIONS OF THE OLDER MESOZOIC DEPOSITS OF ARIZONA.

The geology of the Grand Canyon region of northern Arizona has received much attention on the part of geologists, and considerable has been written on the higher beds of Mesozoic age that lie to the eastward and northward, but very little study seems to have been made of the Little Colorado Valley above Coconino Point, where it broadens out into a plain. The strata of the Grand Canyon up to and including the junction of the Little Colorado with the Colorado River consist, as all know, entirely of Paleozoic and pre-Paleozoic rocks, and it is the Carboniferous limestones, or sometimes sandstones (Upper Aubrey), that occupy the surface of both the Colorado and the Kaibab plateaus. But the entire system dips sensibly to the northeast, and at any point some distance back from the canyon remnants of Mesozoic rocks occur for many miles to the west of the Little Colorado. That river, therefore, practically flows for almost its entire length over Mesozoic strata, but these do not attain their great development except on the northeastern slope of the valley. Here they form several series of terraces, rising one above another backward from the river, and forming at their maximum development lofty and picturesque escarpments, with brilliantly colored stratification, rivaling in many respects the Grand Canyon itself. The broad, arid plains that lie to the southwest of these cliffs have received the name Painted Desert, from the circumstance that from any point on this desert these "painted" cliffs are always in full view. From a great distance they may under certain conditions appear beautiful and innocent, but any attempt to invade this desert or to scale these cliffs, except by means of the few well-known Indian trails, is certain to be met with defeat, and the hardships that have to be endured in striving to traverse this region are of the severest kind.

Very little seems to be known of the more detailed nature of these deposits. They are usually spoken of as a single great group of beds, and I am not aware of any serious attempt to subdivide them or arrange them into anything like successive formations. It was my chief object during my stay in that country to subject these deposits to a searching analytical study and to work out if possible their true succession. I began this study, as already shown, by a reconnaissance of the Little Colorado Valley. After making camp at Tanners Crossing, which is only 12 miles above the point where the Little Colorado enters the limestone canyon at the foot of Coconino Point, I set about mastering the details of the stratigraphy of that general region. Later on, and in the light of information thus obtained, I studied the various remnants of the Mesozoic that are scattered over the Colorado Plateau, and especially Red Butte, which is the most conspicuous and best known of these remnants. Finally, as a concluding task, I returned to the upper portion of the valley of the Little Colorado and made a study of the group there similar to that which I had made below.

I shall be obliged to omit a great amount of important data, including many sections recorded in my notebook, and shall give only the most general and essential results and reproduce the general sections that most clearly illustrate the phenomena.

I think that I have succeeded in dividing the group into three entirely distinct formations. One of these, the thickest of them and the one which is best known, has already been named by Major Powell the Shinarump.[a] This, however, occupies the central portion of the beds in their geological sequence. The other two divisions are, so far as I am aware, unnamed. The lower beds I therefore designate the Moencopie beds, from having first found them in their full development at the mouth of the Moencopie Wash. To the other, or highest formation of the group, I have thought it appropriate to give the name Painted Desert beds.[b]

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[a] Geology of the Uinta Mountains, etc., 1876, pp. 68–69. See Twentieth Ann. Rep. U. S. Geol. Survey, Pt. II, 1900, p. 318.

[b] The name "Painted Desert" occurs, apparently for the first time, in the contents to Chapter IX of Part I of Lieutenant Ives's Report upon the Colorado River of the West, pp. 15 and 113, but is not used in the description of the desert on pp. 116–117. It is used by Doctor Newberry in Part III, on pp. 76–83, and to it he devotes a section. These early uses of the term show that it refers to an area lying opposite to the region between Wolfs Crossing and Winslow, but Doctor Newberry says (p. 76) "that the peculiar physical aspect and

THE MOENCOPIE FORMATION.

These occupy the lowest portion of the group, having a maximum observed thickness of between 600 and 700 feet. They present several distinct phases, but the greatest part of them consists of dark-reddish brown, soft, laminated, argillaceous shales, nearly destitute of silica, highly charged with salt[a] and gypsum, tending on exposure to assume the character of nearly homogeneous marls and to form low ridges, buttresses, and even isolated knolls or buttes, at the bases of cliffs and in eroded valleys. The gypsum often forms thin sheets which appear as fine white lines and which do not follow the planes of stratification, but cross the beds irregularly and also cross one another, giving the exposures a peculiar striped appearance.

Between these beds of shale there occur, usually at more than one horizon, brown sandstones. These are more or less argillaceous and their

geological structure of the Painted Desert prevail over a wide belt of country bordering the Little Colorado on the east, and extending at least as far northward as our camp 73." This camp appears from the very imperfect map accompanying the report to have been about on the latitude of Tanners Crossing, but far to the westward. On this map the Painted Desert is represented as occupying all that region lying along the southwestern base of the painted cliffs from the line of their route through the gap at Blue Peaks and Pottery Hill northwestward to an indefinite distance. On the latest Land Office maps, however, it seems to be restricted to that portion of the desert lying north of the Moencopie Wash and along the base of Echo Cliffs. There seems to be no good reason for thus restricting it.

[a] An artesian well was bored at Adamana, on the Santa Fe Pacific Railroad, 8 miles north of the Petrified Forest and in the valley of the Rio Puerco. At a depth of 305 feet water was struck which had sufficient force to rise 19 feet above the surface and discharge 25 gallons per minute. The water was very salt, reported at 3 per cent chloride of sodium, so as to be wholly unfit for any use. Mr. James Swainson, in charge of the work, which was done by the American Well Works of Aurora, Ill., was good enough to send me the log, which is as follows:

Record of well boring at Adamana, Ariz.

	Feet.
Surface sand and adobe	55
Sandstone	3
Cement gravel	1
Sandstone	29
(Water at 88 feet only slightly salt.)	
Sandstone	20
Brown shale	43
Red shale	49
Hard brown and blue shale	5
Red shale	70
Sandstone	10
Hard brown shale	20
(Intensely salt water.)	
Total	305

The lower 200 feet of this section clearly belong to the Moencopie beds.

exposed faces do not present sharp angles, but have rounded forms, due in the main to the influence of winds, which wear off the jagged appearance but do not tend to form chimneys or assume fantastic shapes. These sandstone ledges, which are very uniform in composition, sometimes have a thickness of 100 feet or more, though such heavy beds are usually interrupted by several layers of the shale.

Toward the lower part of the Moencopie beds the shales gradually become calcareous, and there is in nearly all good exposures a horizon of white, impure limestone, well laminated in its central portion, but becoming very thin and hard below and finally passing either into the typical shale or into homogeneous marls. The extreme upper and also the extreme lower portions of the Moencopie beds always consist, so far as observed, of the typical dark-brown argillaceous shale, and the whole series, wherever the contact can be found, always rests in marked unconformity upon the underlying Paleozoic rock (Upper Aubrey). It is very probable that the lower portion of the Moencopie beds belongs to the Permian.

THE SHINARUMP FORMATION.

This constitutes a vast assemblage of strata with a maximum observed thickness of at least 1,600 feet. It presents a number of phases, some of which are so distinct that if studied in only one locality they would naturally be regarded as separate subdivisions, but such a general survey as I have been making points to a certain homogeneity in all these beds, or at least establishes the unmistakable tendency toward the recurrence in any of the phases of features that are prominent in other phases. The Shinarump constitutes the horizon of silicified trunks, and there is no part of it in which fossil wood does not occur in great abundance. It also marks the limit of the wood-bearing deposits of this region. For this reason alone, in view of the etymology of the name, I should be justified in extending the Shinarump as far as the fossil trunks occur, and it is obvious from the language used that Major Powell had the upper portions of the formation in view as well as the lower when giving the name, although other geologists, in speaking of the Shinarump, usually seem to have in mind only those beds which he called the Shinarump conglomerate. It is doubtful, however, whether the remainder of the formation has really been studied or carefully observed by others.

I shall divide the Shinarump into two somewhat distinct parts and call the lower the Lithodendron member and the upper the Leroux member.

THE LITHODENDRON MEMBER.

This division is the equivalent of the Shinarump conglomerate of Powell, and I was at first disposed to retain his name under the rule of priority, and did so in my preliminary paper,[a] notwithstanding the far greater development and marked change of character which it assumes in the upper part of the Colorado Valley. Attention has been called to the fact that the use made by Major Powell of the name Shinarump conglomerate for a part of a larger group which he called the Shinarump is likely to lead to confusion and is generally objectionable. I shall therefore drop that term, except as descriptive of the conglomerate beds that occur in the Shinarump, and shall call the part of the formation in which these conglomerates occur the Lithodendron member. This term is specially appropriate not only because of the stone trees that constitute the most prominent feature of the beds, but also because the name was given by Lieutenant Whipple in 1853 to the stream or wash in which petrified trunks were found in great abundance by his exploring party when it passed through that region.[b] This was there called Lithodendron Creek, and it was from the bed of this creek that the two trunks brought to the United States National Museum in 1879 by Lieutenant Hegewald were obtained, these being the only ones that have thus far been studied from the standpoint of their internal structure. The creek lies in the region where the Lithodendron beds attain their maximum development and only a short distance from the Petrified Forest which it has been proposed to set apart as a national park.

Although perhaps the most prominent feature of this formation is the so-called conglomerate, which sometimes is in truth deserving of that name, and contains somewhat large but always well-worn pebbles and cobbles derived from underlying formations, it rarely happens that this aspect of the beds constitutes the major portion of them. In the first place, the conglomerate tends to shade off into coarse gravels and

[a] Geology of the Little Colorado Valley: Am. Journ. Sci., 4th ser., Vol. XII, No. 72, December, 1901, pp 401–413.

[b] Report of Explorations and Surveys to ascertain the most Practicable and Economical Route for a Railroad from the Mississippi River to the Pacific Ocean, Vol. III, 1856, Pt. I, pp. 73–75; Pt. II, p. 28; Pt. IV, pp. 43, 150, 151, 167.

then into true sandstones. These sandstones are of a light color, contrasting strongly with the dark-brown sandstones of the Moencopie already described. They are, moreover, always more or less cross-bedded and usually exhibit lines of pebbles running through them in various directions. These are true sandstones, very hard, devoid of alumina, and scarcely affected by the winds, so that their angles are usually sharp and the ledges they form are abrupt and jagged. Although the sandstones proper generally occur lower down, there is no uniformity in this arrangement, and sandstones are often found in the middle and conglomerates more rarely at the top. But in addition to these the Lithodendron member embraces other classes of beds. There is a well-stratified layer of thinnish sandstone shales that is often seen immediately under the heavy sandstone cap. Some of these shales have a grayish color and are highly argillaceous. These layers tend to thicken even within the member itself, but especially farther out, and, what is more significant, they often become transformed into a bluish white marl. This condition can be seen between the beds of conglomerate in places where the Lithodendron beds are comparatively thin, as in the lower valley of the Little Colorado, where they are only about 300 feet in thickness. This feature is not very prominent, but at other places, as in the Petrified Forest region, where the Lithodendron beds attain their maximum thickness of 700 or 800 feet, this tendency on the part of certain beds to become transformed into marls is the most marked feature of the member. The marls here occupy much more than half of the beds. They are very varied in color, showing besides the white and blue tints a great variety of darker ones, such as pink, purple, and buff. These heavy marl beds, of which there may be several in the same cliff, are interstratified between conglomerates, coarse gravels, and cross-bedded sandstones, all of which taken together form the beautifully banded cliffs that are seen throughout the Petrified Forest, especially along its northern flank. It thus becomes necessary to include under one designation all of these varying beds, which often change the one into the other even at the same horizon within short distances.

It remains to mention certain minor features, which are not universal, but which nevertheless have considerable importance. In the

lower Little Colorado Valley there occur numerous somewhat calcareous clay lenses, the lime taking the form of bright white stripes, while the clay is usually purple or pink. These are very distinct objects and vary in size from lenses 10 or even 20 feet in length to small lenticular blocks or somewhat oval or even spherical clay balls or pellets. These calcareous clay inclusions are scarcely seen farther to the southeast, but on Red Butte they are well marked, and here the clay becomes brilliant red and constitutes a true paint stone. Another fact to be noted in connection with the Lithodendron beds is that at certain localities, notably on Red Butte, there is at its base a clear indication of a transition to the Moencopie formation. The conglomerates proper are underlain by argillaceous shales closely resembling those of the Moencopie, but beneath these is a sandstone ledge which can not be referred to the lower division, as it is more or less cross-bedded, possesses considerable grit, and has included in it small clay pellets similar to those of the true conglomerate series, in which I have for this reason included it. This condition of things may be somewhat puzzling from the stratigraphical point of view, but the disadvantage in this respect is much more than compensated for by the evidence that it furnishes in favor of the view that all of these beds really constitute one great series, and as opposed to the view which it may be inferred that certain geologists hold that the series of these beds which I have included under the name of Moencopie belongs to a different system and is in some way connected with the underlying Paleozoic rocks. This view, in the light of the above-mentioned facts, is, in my opinion, quite untenable.

THE LEROUX MEMBER.

Under the name Leroux I include the remainder of the Shinarump, deriving the name from Leroux Wash,[a] which enters the Colorado Valley 2 miles below Holbrook, and on which, some 15 miles north of Holbrook, this member attains the greatest development that I have observed, probably reaching its maximum of 800 feet. These beds, too, if studied at localities where they are less developed, might be sup-

[a] The name "Leroux's fork" was given to this wash by Lieutenant Whipple's party, who followed it down some distance and encamped at its junction with the Little Colorado on December 5, 1853, this being their Camp 79. See Pacific Railroad Reports, Vol. III, Pt. I, p. 75. The name is written in two words on the Land Office map of Arizona.

posed to form several quite distinct subdivisions. Indeed, I was of this opinion during most of my stay in the lower Little Colorado Valley, but even before leaving there the proofs of their homogeneity had become apparent.

At least the lower half consists of those remarkable beds in which I had originally found the vertebrate bones in 1899, and in which alone thus far vertebrate remains have been observed. I have sometimes designated them the variegated marls and sometimes the Belodon beds. The distinguishing feature of these beds is the presence of great numbers of small buttes, the smaller ones appearing to be blue clay knolls, but the larger ones showing other colors, especially purple, and sometimes several bands of different hues. Almost everywhere at this horizon there exist plains, dotted all over with these remarkable little buttes, varying from 3 or 4 feet to 20 or 30 feet in height, usually isolated from one another and having a form peculiar to them. They are not conical in the true sense of the word, since they do not rise to a point at the summit, but are always rounded off and have the form of a well-made haystack, the smaller ones looking like haycocks in a field. These butte-studded plains are of course simply the remains of a plateau or mesa which has been worn away, primarily by the action of water, but for a very long period there can be no doubt that wind has been the more potent agency. There is evidence throughout that entire region that the amount of precipitation was formerly much greater than at present, and in so speaking I do not refer to a very remote date geologically, but to a period which was probably post-Tertiary. Indeed, from the present condition of many of the regions in which we know that the early Indians dwelt and which are now perfectly dry, with all sources of water so remote that they can no longer be inhabited, it must be inferred that there has been a change in the climate within the period of human occupancy. Certain it is that water is doing very little relatively in this region now, while the agency of wind is conspicuously marked wherever it can produce effects. The peculiar form of these buttes is not such as water could have produced, while it is precisely the form that wind would naturally produce, acting upon the very fine and soft materials, somewhat resembling ashes, that compose these buttes.

Further evidence of this is found in the fact that in approaching the general escarpment which bounds these plains the buttes tend to lose their isolated character and form ridges projecting out from the cliffs. It never happens that an entire valley or plain is covered by a single system of buttes. These systems are separated by wide intervals, often of nearly flat country, but through which it can be easily seen that water once flowed, at least in the form of temporary floods, and in such a manner as to have swept away every vestige of the former plateau, and in crossing which there are encountered one or several wide beds to which the term "wash" is popularly applied. In descending the Little Colorado this condition of things, as already remarked, is not met with until within 8 or 10 miles of the Lees Ferry road. A large system of buttes is then found extending 5 or 6 miles down the river and across the plain to the first terrace, a distance of 3 to 5 miles; then occurs the first wash, 2 miles in width, followed by another system of buttes, which is nearly due east of Tanners Crossing, and in which most of the bones were collected by our party. There is then another wide wash; the next system of buttes, however, does not reach the river, but trends off in a direction nearly due north. There is still another wash before the great Moencopie Wash is reached, the direction of which is such as to be highly favorable for the preservation of these buttes, and accordingly we find their greatest development, so far as this region is concerned, along the Moencopie Wash. They do not, however, follow the stream up in the direction of Tuba, but continue to trend northward along the wide valley that lies to the west of Willow Springs and Echo Cliffs.

The reason why these conditions are not earlier met with in the valley of the river is simply that the river does not follow the line of strike, and these beds, being common to the entire member, lie at different distances from the river. Above the point mentioned, therefore, they must be looked for farther in the interior. We found them, in fact, 5 miles east of Black Falls, or 25 miles southeast of Tanners Crossing. The great bend in the river culminating at Winslow keeps these beds constantly so far to the northeast, in a region where it is very difficult to penetrate, that their exact condition for a distance of over 50 miles is little known. But farther up the river, where they approach somewhat to the region of settlement, they again admit of access, and, as already remarked, they

appear in great force in the valley of Leroux Wash. Here they cover an area of nearly 100 square miles and form two great amphitheaters of veritable badlands. The great variety and symmetry in the form of these buttes and ridges, however, as well as the variegated and iridescent colors that prevail, render them a magnificent spectacle. They can be seen from the southeast for a distance of 20 miles as a white line. Viewed from the top of the mesa out of which they have been carved, the denudation having been arrested at a particular point, they reveal more completely than at any other place the true character of this member. In the Petrified Forest the Leroux beds are also well developed, and the variegated marls are found only half a mile east of the Lower Forest. The buttes here are rather large and well developed, and bones of the Belodont occur in them. In the northern part of the Petrified Forest region the variegated marls lie somewhat farther to the east. What is called the Middle Forest lies in the midst of them, and the petrified wood, as everybody has observed, differs here considerably in its constitution and coloration from that of the Upper and Lower forests, which lie in the horizon of the conglomerate member.

As was remarked when treating of the conglomerates, these variegated marls are actually found stratified between the sandstones by the transformation of certain shales into marls. If these beds are carefully traced a short distance in the direction of the dip they will be seen to thicken very rapidly and soon to take on the character of the true variegated marls. As they start from underneath a bed of sandstone which caps the conglomerates, and which does not so readily pass into marl, the buttes that are first formed are usually topped out by a block of this sandstone, and it is necessary to proceed some distance farther in the direction of the dip to reach a point where the sandstones disappear. This, however, ultimately takes place and the marl beds thicken to such an extent that they have to be regarded as virtually overlying the conglomerates. In fact, in the bed of the Moencopie Wash, on both sides of which these beds are so well developed, the conglomerates can be seen distinctly passing under the marls.

For the purposes of our expedition the variegated marls constituted the most important subdivision of the entire group. But as we have seen, their maximum thickness is about 400 feet, and there remain still

another 400 feet before we reach the base of the painted cliffs. Throughout the whole of this fossil wood is abundant, but the character of the beds as variegated marls no longer continues. In the lower Colorado Valley, where I know it best, the variegated marls are succeeded by a sandstone ledge at least 100 feet in height, yielding black logs of very fine structure. At this point these sandstone beds constitute an escarpment and form a small terrace, the summit of which is a dip plane. Upon this lie the remains of the next set of beds, which are somewhat remarkable, primarily in being essentially limestones, but they consist mainly of loose material somewhat resembling dried mortar, for which reason I have designated them mortar beds. They are, however, very irregular in structure and contain much impure flint and large flinty stones. In the midst of them there occurs a true limestone ledge, well stratified, succeeded by a continuation of the mortar beds. In the region mentioned these beds extend to the limit of what I regard as true Shinarump, and petrified wood was found above the limestone ledge.

A wider acquaintance with this part of the member shows that the conditions above described do not hold at all points and may even be regarded as exceptional. Nowhere else except at Black Falls did I find the lower sandstone ledge, and at most other points the limestones gradually supervene upon the variegated marls. In fact, not only the variegated marls, but also the shales of the conglomerate member, which become transformed into marls, are more or less calcareous; and as the entire upper portion of the Shinarump consists mainly of limestones and calcareous materials, we may regard all of this, including the variegated marls, as virtually a calcareous deposit. If we were to look for its homologue in the Trias of the Old World we should find it in the Muschelkalk, while the conglomerate member might well be compared with the Buntersandstein, and the Painted Desert formation with the Keuper, to which the French term Marnes Irisées is only locally applicable.

In the extensive exposures on Leroux Wash these relations are brought out with great force. Overlying the true variegated marls which stretch out for a distance of 3 miles across the broad eroded valley, the limestone series comes in gradually and scarcely differs, except in the degree of calcareousness, from the underlying beds; but the limestone ledge is ultimately reached and is sharp and definite. It has a thickness of about 10 feet. Over it lie very heavy beds of calcareous materials,

beginning as mortar beds, such as I have described, but soon taking on more symmetrical forms, closely resembling the marl buttes of the valley below. The color also changes, and many of the buttes are, in whole or in part, of a deep blue or a lively purple. These constitute here the highest beds of the Shinarump, and fossil wood is abundant throughout. Much the same conditions prevail in the Petrified Forest region, but the development is here much less extensive.

THE PAINTED DESERT FORMATION.

It remains to consider the third and highest formation of the Older Mesozoic of Arizona. As already stated, these constitute the elevated cliffs that bound the valley of the Little Colorado on the northeast. Although broken through in many places, and practically wanting for long distances, they constitute what may be regarded as a great wall, separating the valley from the region of high mesas that lie in the Moqui and Navajo country. As these beds seem to contain no fossil remains, and as they are throughout the greater part of their extent practically inaccessible because of the absence of water, their detailed study has been neglected, and I was able to acquaint myself with them only imperfectly and at a few points.

There is, however, no place where they are better developed than directly east of Tanners Crossing, where we remained longest, and on several occasions the attempt was made to reach them from our camp and to examine them closely. Enough was learned to justify the positive statement that they consist almost entirely of sandstones, perfectly stratified, the different layers differing mainly in color, thickness, and fineness of structure. The great central portion constituting the escarpment and having a thickness of about 800 feet is, within these limitations, practically homogeneous. The series begins, however, with a bed of orange-red sandstone, highly argillaceous, and soft in structure, easily eroded, and readily yielding to the influence of wind. It has a thickness of about 100 feet, and in the lower Colorado region stretches across the broad valley at the base of the escarpment and lies directly upon the uppermost limestones of the Shinarump. Here it forms picturesque and fantastic buttes and chimneys standing out upon the plain. It occurs in the same position overlying the Shinarump on Leroux Wash and forming the top of the mesa which overlooks the

amphitheater that I have described. It is also seen above the Shinarump to the east of the Petrified Forest. It is therefore probably safe to assume that this formation is continuous from Echo Cliffs to the boundary line of New Mexico.

Of the painted cliffs there seems to be little more to say. In looking at these cliffs from a distance it is seen that they are overlain by a white formation, the nature of which it is important to consider. Before we had visited the region, so as to obtain a close view of them, it was natural to suppose that they might constitute Jurassic limestones and that the Triassic system might terminate at the line which separates them from the variegated sandstones. But upon close examination this was found not to be the case, and these white rocks were found to consist of sandstones, often very pure and cross-bedded, with scarcely any admixture of marl. These, without question, constitute the summit of the Triassic system in this region. They are, however, not always white; or at least in some places, as, for example, in the vicinity of Tuba, they are underlain by a still thicker bed of soft brown sandstone, which is somewhat argillaceous and easily worn by the wind, forming chimney buttes and ruins. This bed has a thickness along the headwaters of the Moencopie Wash of about 200 feet, and is overlain at the highest points by the white sandstones to a thickness of 100 feet more. These sandstones are very porous and all the waters that fall in that region immediately pass through them; but as they approach the summit of the much harder and firmer beds that constitute the lower formations these waters are arrested and come out in the form of springs, sometimes almost of small rivers, along the crest of the cliffs above the Moencopie Wash. It is on one of these springs that the little Mormon town of Tuba is located, and this is true also of Moa Ave, Willow Springs, and other settlements in that country. Still farther back the Cretaceous lignites and limestones lie unconformably upon these uppermost sandstones of the Trias, and the Jurassic is wanting altogether.

PALEONTOLOGICAL RELATIONS.

Having thus briefly sketched the stratigraphical relations of the Older Mesozoic rocks of Arizona, I shall next consider their paleontological relations, in so far as they were ascertained on this expedition, as shedding light upon the age of the group.

THE MOENCOPIE FORMATION.

These beds have proved almost entirely barren, no fossil bones having been found in the calcareous marls of the lower part and no fossil wood anywhere in the formation. It is, however, proper to remark that in the bed of the Little Colorado River about 3 miles below Tanners Crossing, on the surfaces of certain flags that underlie the conglomerate member, and which I had therefore referred to the Moencopie beds, there were found impressions of coniferous twigs and short stems, showing, however, very little structure. In some cases the impressions showed that the branches surrounded the stems in the form of whorls. At first they recalled impressions of Equisetum, but fuller investigation showed that they were coniferous stems, with the characteristic whorled branching of the Araucarian type, to which the fossil wood of this region probably also all belongs. As such these vague impressions have great value in showing that this type of vegetation continues to be found in the lowest beds in which any plants occur. The question whether these flags actually belong to the Moencopie beds is, however, an open one. At the time of our discovery I had no doubt on this point, but after finding the transition beds on Red Butte and in the Little Colorado Valley, it becomes possible to refer some portions of the beds that underlie the true conglomerates in the lower region to the conglomerate member. But it thus becomes scarcely more than a question of names and no longer raises a serious problem.

There is only one other reported fact that need be considered in this connection. Mr. P. C. Bicknell, who was my guide in the region of Red Butte, and who has spent much time in studying the rocks of that region, informed me that he once found in the light-colored calcareous shales at the base of the butte some faint impressions of fern leaves, which were for the most part too frail to be transported, but that there was one which he took to the Anita mine and compared with certain figures in the few books at hand, and it seemed to him nearest to the figures of some species of Callipteris. The specimen, however, ultimately disintegrated and was lost. On the occasion of our visit he took me to the place and we made diligent search for other specimens, but nothing of the kind could be found. If the species was really a Callipteris it would indicate a Paleozoic age, but as Mr. Bicknell had read in the books that treat of Red Butte that it was a Permian

remnant, he naturally looked among Permian fossils for a figure with which to compare his specimen and does not seem to have looked further. The Trias also yields ferns, and perhaps if he had examined figures of Triassic ferns he would have found a figure of his plant. It is at least certain that this defective piece of evidence is altogether without weight in fixing the age of these beds.

THE SHINARUMP FORMATION.

So far as concerns the vertebrate remains, sufficient has already been said to show that all that were found came from a single phase of the Shinarump formation, viz, the variegated marls. They occur in general a little higher than the middle and 200 to 300 feet above the top of the conglomerates. Very few other animal remains were found, but Mr. Brown did collect a small number of shells and a few other invertebrates. They are probably for the most part without diagnostic value, but as they have not yet been determined it is impossible to discuss their significance.

The only plant remains that I was able to discover, aside from what belong properly to the fossil trunks, were certain forms occurring in relief on the faces of sandstone rocks and shales. They consist of stems having the Araucarian structure and showing the branches in whorls, and of the raised casts of small twigs lying across one another in all directions. No signs of the structure nor any carbonaceous material accompanies these impressions, and they seem to have resulted from the etching away of the sandstone from between the twigs while still in the beds, so that when subsequently exposed these markings stand out very distinctly, though always somewhat worn. They probably all belong to the coniferous vegetation, but have very little value in determining its exact nature. For convenience of reference in future I shall name these forms *Araucarites shinarumpensis*. (See Pls. I, II.)

No one who has not visited that region can form an adequate conception of the inexhaustible quantity of silicified wood that occurs at all horizons. The condition of things in the Petrified Forest has already been set forth by others as well as myself.[a] It strongly attracted the attention

[a] Twentieth Ann. Rep. U. S. Geol. Surv., Pt. II, 1900, pp. 324–332. Report on the Petrified Forest of Arizona, by Lester F. Ward, Washington, 1900 (special publication of the Department of the Interior). The Petrified Forest of Arizona, by Lester F. Ward: Smithsonian Report for 1899, Washington, 1901, pp. 289–307, pl. i–iii (reprint of the last with three plates added).

of all the early exploring parties that passed through that region, although it is next to certain that none of these parties ever saw what is now called the Petrified Forest. They all passed within a few miles of it, but either kept in the bed of the Rio Puerco or else some distance to the northwest of it. Lieutenant Whipple's party crossed that stream at Navajo Springs and followed it down at considerable distance from the valley on its right bank, crossing a number of broad washes, which they named. The first of these washes that they crossed after leaving Navajo Springs is now called Bonito Creek on nearly all maps. It joins the Rio Puerco about 6 miles below Navajo Springs. The next wash that the party crossed they named Carrizo Creek. The third of these valleys or creeks was the one in which they found such a great quantity of beautifully colored petrified wood, and from this circumstance named it Lithodendron Creek.[a] There are, of course, vast quantities of petrified wood on the slopes of all these streams or valleys. The range of mesas that skirts the northern flank of the Petrified Forest trends here considerably to the north and reappears on the northwest side of the Rio Puerco only a few miles below Carrizo, to the northeast of which these mesas are worn away much as they are in the Petrified Forest, leaving the petrified wood strewn over the valleys and ridges, so that the conditions obtaining on Carrizo Creek or Lithodendron Creek are very nearly the same as those of the Petrified Forest. The wood is not so abundant there and is not generally so brilliantly colored, but some of it is jasperized and is very beautiful. The two great logs that were brought to the National Museum in 1880 or 1881

[a] In my report on the Petrified Forests of Arizona (p. 10), I pointed out the fact that Lithodendron Creek could not by any possibility pass through the present petrified forest, although a number of writers have alluded to the valley in which that forest is located as Lithodendron Creek. And in the Twentieth Annual Report, Pt. II, p. 324, I again mentioned this fact and stated in a footnote that Lithodendron Creek was probably what is now called Carrizo Creek on the Land Office map, and which joins the Rio Puerco at what was long Carrizo station on the Santa Fe Pacific Railroad, now abandoned. I have taken the trouble to verify this conjecture, which proves to have been correct. On consulting in the Engineer Department of the Army a map published in 1883, entitled "Map of the Territory of the United States West of the Mississippi River, prepared in the office of the Chief of Engineers, U. S. A., under the direction of Brig. Gen. H. G. Wright, Chief of Engrs., Bvt. Major-General, U. S. A., by W. W. Winship, D. Callahan, Louis Nell, and J. R. P. Mechlin, 1883," I find that Lithodendron Creek is the name given to the wash that joins the Rio Puerco at Carrizo, which is called Carrizo Creek on the Land Office map. Its course and character are identical on the two maps, and are correct, as I have myself taken occasion to prove by actual observation. On the map above mentioned, however, the next stream above, which is called Dead Creek on the Land Office map, is named Carrizo Creek, but is made to join the Rio Puerco at Billings instead of 5 or 6 miles below, as Dead Creek is represented to do. Their courses are very different, and I have not personally verified the accuracy of either of these maps. It is, however, no longer a question that Lithodendron Creek is the dry wash which unites with the Rio Puerco at Carrizo.

were transported from Lithodendron Creek by an expedition headed by Lieut. J. T. C. Hegewald in the spring of 1879.[a] The only species that has yet been described from the silicified wood of Arizona is the *Araucarioxylon arizonicum* of Knowlton, based on specimens from these two trunks. Neither of these trunks is colored, but both of them show structure. The importance of these specimens, therefore, and of the locality at which they were found will be readily understood.

At the time I made the investigation upon which my report was based I was imperfectly acquainted with the geological relations of the formation in general, as set forth above, and I treated the subject from the narrower standpoint of such a knowledge of the immediate region of the petrified forests as I was able to acquire in the short time devoted to their study. I did not in my report even so much as mention the Shinarump conglomerate, although I believed at the time that the coarse gravels in which I found the logs in place really belonged to it. I was, however, mistaken in supposing that there was only one bed of this conglomerate and that the rocks forming the summit of the mesa on which the Natural Bridge is situated were the same as those observed on the southwest side of the general area. The last-mentioned beds dip rapidly to the northeast and come down within 100 or 200 feet of the bottom of the wash which passes through the Lower Forest. The occurrence of fossil wood in place in a very low position a few miles north of this point, which I was somewhat disposed to attribute to faulting, is the perfectly natural result of the regular way in which these beds decline to the eastward. The mesas in the northern part of the forests, including that of the Natural Bridge, have at their summits an entirely different series of conglomerates, occupying a much higher position in the general system. This succession of several beds of conglomerate one above another, all filled with petrified wood, is sufficient to account for the vast quantities that have accumulated since the breaking down of these cliffs and the washing away of the intervening marls, so that the necessity for a theory of extensive transportation is practically removed. It is probable, however, from the considerations set forth in my report, that most or all of the logs were drifted some distance before being laid down in the position in which they occur.

[a] See his report in Proc. U. S. Nat. Mus., Vol. V, 1882, pp. 1–3.

This brilliantly colored petrified wood comes chiefly from the true conglomerates; and, as already remarked, that of the so-called Middle Forest, which lies farther to the east and has weathered out of the variegated marls, is less brilliant, though scarcely less abundant. At the base of these same marls on Leroux Wash, especially at the lower end of the system, great quantities of logs lie out upon the plain. They have a reddish-brown color, are very large, and look at a distance like so many rusty locomotive boilers. They are broken across into sections. Most of the wood at this horizon, however, is not colored, and it has usually undergone a higher degree of disintegration than the harder trunks from the conglomerates. It shows the structure admirably, at least to all outward appearances, and the sections are usually split up into a large number of blocks and ultimately reduced to a mass of chips and splinters, which look so natural that they would not be suspected of being petrified unless picked up and examined closely. Many of the smaller buttes seem to have been occasioned by the presence of logs, which weighted the underlying marls and tended to prevent their being washed or blown away. The result is that many of these buttes have such logs lying on their summits, with the disintegrated material rolling down its slopes.

In my report on the Petrified Forests of Arizona (p. 15) I mentioned the statements made by Möllhausen and Marcou that they had seen trunks standing erect and evidently in place, and I quoted (p. 16) Doctor Newberry's conclusion, agreeing with mine, that this phenomenon probably did not occur. So far as the conglomerates are concerned, I have seen no reason for altering this conclusion, although I would not be as positive now as I was then that cases of the kind will not be found. But with regard to the trunks entombed in the variegated marls, or next horizon above the conglomerates, we practically demonstrated that erect stumps do occur in them. Within a quarter of a mile of the butte from which Mr. Brown found the best preserved vertebrate bones there is a small area, probably 30 or 40 acres, which contains a group of twenty or more such stumps. They are low, rarely rising more than 4 feet above the ground, but some of them are large, having a diameter of from 3 to 4 feet. Nearly the entire trunk above these stumps, as well as all the branches, has wholly disappeared, but the ground is strewn with small chips and blocks. It is a somewhat level

area and the stumps all stand erect upon it, and many of them are not deeply buried in the earth, but show the natural enlargement toward the roots. A careful examination of these stumps convinced me that they were not only in place but stood precisely where they grew. Mr. Brown, who discovered this place, is of the same opinion. However difficult it may be to figure to oneself conditions that would preserve trees in an erect position in a sedimentary bed, the fact of their presence in this position seems to be conclusive. The most probable theory seems to be that, as a matter of fact, the trunks of the trees were not preserved, but only the roots and short stumps, and whatever the conditions may have been that were sufficient to preserve large trunks in a horizontal position, the same conditions would surely preserve such short stumps and roots.

This seems the proper place to mention another phenomenon which at first was very enigmatic and which can not yet be said to be adequately explained. I found on several occasions some peculiar short chalcedonized stems contracted at both ends, many of them broken transversely and showing a concentric structure; others split longitudinally. I observed that these varied in length relatively to their diameter until some of them became merely elliptical objects resembling fruits. It was not until the erect stumps, above described, were discovered that the mystery was partially cleared up. Among the chips and blocks that surround these stumps there occur a large number of these elliptical fruit-like objects, usually striate on the surface and somewhat flattened, so that the cross section is elliptical. This is the typical form and much resembles a butternut that has lost its exocarp, but a very little search reveals the fact that there are great variations from this norm, especially in the matter of lengthening the axis. Then it is soon seen by specimens that can be picked up that the rounded ends represent constrictions between two of the objects, and that they are arranged primarily along a general axis in a necklace-shaped series. The next and most important fact that comes out is that these rows of nut-like objects adhere to the true fossil wood in the interior of the trunk and are often actually found in place in the stumps as an integral part of their structure. This, of course, reveals their true character as simply accumulations or secretions of certain substances within the trunks, and everything points to the probability that they consisted

originally of resin or pitch. They may, therefore, perhaps be correctly designated pitch blisters and compared with the blisters of Canada balsam that occur in the bark of the balsam fir. Further than this they have no botanical significance. A rather large collection was made, showing all the different aspects and furnishing data for the above conclusion. (See Pl. III.) The species may be called *Araucarites monilifer*, alluding to the necklace-shaped rows of resin drops.

I had been several times told that petrified cones had been found in connection with the fossil wood of this region. While at Stanford University in October, 1899, a young man named Dane Coolidge gave me an account of such a discovery made by him and his father at a point 4 miles west of Williams, Ariz., some years before. He said they found large petrified logs, in the vicinity of which they picked up a number of fossil cones. He wrote to his father and obtained for me all there was left of their collection. It contained nothing recognizable as a cone, but he said that all the good ones had been given away. As I was going into that country, I thought it worth while to stop and examine the spot, which was very minutely described for me. I found no trunks or petrified cones, but did find a few pieces of unmistakable fossil wood. The locality is near Supai, on the Santa Fe Pacific Railroad, where there is a dangerous curve.

A short time afterwards I was shown, at the house of Mr. T. W. Brookbank, at Little Spring, on the northwest side of San Francisco Mountain, a number of objects which were believed to be fossil cones. They were not sufficient for me to settle the question, but I was told that Mr. Brookbank, who was then away, had much more perfect ones locked up in an adjacent room. These Mrs. Brookbank said were collected on blue clay knolls near Tanners Crossing of the Little Colorado. The ones I saw were cylindrical bodies, of a reddish-brown color, surrounded by quartz crystals, closely imitating the scales of cones. Two weeks later I visited that region, but found nothing that looked like these specimens. My stay there, however, was too brief to enable one to find anything rare, and therefore when I went there this season and devoted more than two weeks to the minute study of the wood-bearing beds of that locality I paid particular attention to the search for fossil cones. I found none, but did find many cylindrical objects, some of them surrounded by crystals, which were certainly the same as the

alleged petrified cones of Mr. Brookbank. In passing his house, on our way to Flagstaff, Mr. Brown and I were kindly permitted by Mr. Brookbank to examine all the fossils in his possession. None of the supposed cones were such, and all of them belonged to the same class of materials that I have described. Although they are not cones, they have some paleobotanical interest, and I made a thorough study of their origin and nature. They occur in the Petrified Forest and elsewhere, are usually spoken of by the inhabitants of the country as stems, and are supposed to be the smaller branches belonging to the upper part of the trees which make up the forest. This, however, is an erroneous view, and I discovered that they always came out of the interior of the trunks and belong to the bodies of the trees. They vary indefinitely in size and length as well as in texture, and only a few of them are surrounded by crystals. They either have to do with the vascular tissues of the trunks or else they are modifications of the pitch blisters described above, and represent lines along which the resin was disposed to accumulate either during the growth of the tree or, more probably, as a result of the process of mineralization, during which these products were segregated and arranged along certain lines. I brought with me a sufficient number and variety of these objects to illustrate their true character.

The petrified wood of Arizona is found widely scattered over the Paleozoic terrane. One small specimen only, picked up by Mr. P. C. Bicknell, was found at the foot of Red Butte, which must have come from the conglomerate bed at the summit. But in the vicinity of Williams, both southwest and east of the town, I found many pieces of unmistakable fossil wood lying about among the dark porous rocks of the lava. They all show the effect of heat, are themselves somewhat porous, and have doubtless lost all their minute structure, but their true nature as wood can not be doubted. I brought away a number of specimens, and also have those collected near Supai two years before. Moreover, I met many persons who reported finding it under similar conditions near Flagstaff and on the north side of Mount Agassiz, as well as farther on in the direction of the Grand Canyon. These occurrences are certainly difficult to explain, especially in view of the fact that, with one exception, no wood has thus far been found below the true Shinarump. It seems necessary to admit that not only the Moencopie beds but also the conglomerate once cov-

ered the entire Paleozoic terrane, at least as far west as Bill Williams Mountain and Supai.

THE PAINTED DESERT FORMATION.

It was remarked that an exception would be noted to the general statement that petrified wood, so far as known, is exclusively confined to the Shinarump. When at Tuba I made an excursion to the northeast, over the brown rocks of that region, and in some of the buttes and chimneys which they form I observed black spots. A casual examination would lead to the supposition that they might be deposits of manganese or limonite. They are mostly black sand, but more extensive observations revealed the fact that they are due to the former presence of trunks of trees, and in one place I found the remains of a log broken into a number of sections. It consisted, however, wholly of the black sand and had lost all signs of structure. Beds of lignite were reported in that general vicinity, and they are probably due to the same cause.

SECTIONS.

Special attention was paid throughout the expedition to working out geological sections of the beds studied. The more important of them will be introduced here as necessary to complete the description of these beds. I will begin with the first section made, which resulted from an investigation of the bluffs of the Little Colorado below Tanners Crossing.

SECTION I.—CANYON OF THE LITTLE COLORADO.

[Pl. IV, A–B.]

There are a few short canyons in the Little Colorado at various points, but it is not until Tanners Crossing is reached that the canyon becomes continuous to the mouth of the river. For several miles the valley even here is somewhat broad, the bed of the stream usually hugging one bluff or the other; but the bluffs are always 100 to 400 feet high and more or less perpendicular, so that it may be practically regarded as a canyon. The fall of the river is here about 25 feet to the mile, and its course is nearly northwest. As the dip of the rocks is northeast this would practically be the line of strike, but the fall in the river is to be taken into account, and it is also true that just at this point the trend of all the different subdivisions is much more northerly, as I have shown in my discussion of the variegated marl buttes. The consequence is that in reality the bed of the river, from Tanners Crossing on, continues to be lower

and lower in its horizon, until at last, some 12 miles below, the Paleozoic limestones appear, and in the very narrow canyon suddenly formed at the base of Coconino Point, which forms the eastern escarpment of the Colorado Plateau, the limestone rocks rise to a height of 100 feet and constitute the canyon proper. The section along the river between these points was carefully worked out by me. The most remarkable fact was that about 4 miles above the limestone canyon there occurs a Paleozoic anticline as viewed from the bluffs, the limestones rising to a height of about 90 feet and again descending to the bed of the river, the length of the anticline being about 2 miles. This of course represents a spur of the Colorado Plateau, running out parallel to it in a northeasterly direction, which was cut through by the river. This is shown in the following diagrammatic section, 12 miles in length:

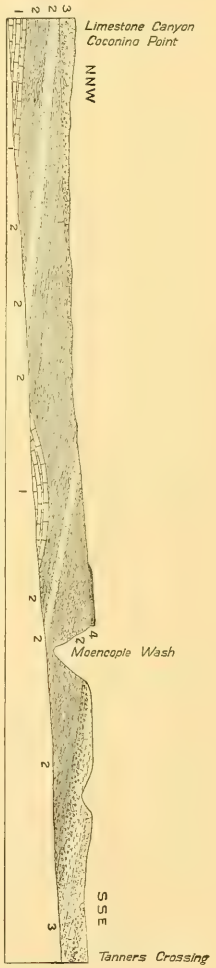

FIG. 1.—Section of the canyon of the Little Colorado, Arizona.

Description of the section shown in fig. 1.

	Feet.
1. Carboniferous limestone	100
2. Argillaceous shales and sandstones, Moencopie formation	200
3. Lithodendron member	125
4. Trap	30
Total thickness	455

The above are the vertical measurements of the beds as seen in the bluffs. Probably twice that thickness of the Moencopie beds is represented, and only the base of the conglomerate series is here exposed.

SECTION II.—MOENCOPIE WASH.

[Pl. IV, C–D.]

This section begins some 5 or 6 miles below the mouth of the Moencopie Wash, opposite the upper end of the limestone canyon. The rocks dip away from the river from the first, and the section remains wholly within the valley of the Moencopie, reaching the bed of it at a distance of

about 7 miles, and following it at that level for about 6 miles more, to where there is a decided bend in the stream which comes in from the east. The Moencopie here runs between high bluffs, and the section shows those of the right bank, passing through Tuba, which is 300 feet above the bed of the Moencopie, and continuing on over the brown and white rocks. The maximum thickness is 3,000 feet and the length of the section 24 miles. The following is the section:

Description of the section shown in fig. 2.

	Feet.
1. Carboniferous limestone	100
2. Moencopie formation	600
3. Lithodendron member	500
4. Variegated marls	400
5. Limestones and mortar beds	200
6. Variegated sandstones	500
7. Brown sandstones	600
8. White sandstones	100
Total thickness	3,000

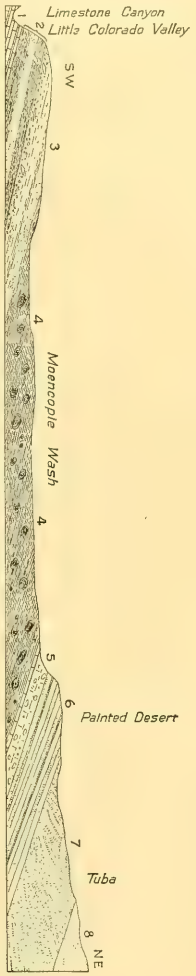

FIG. 2.—Section of the Moencopie Wash, Arizona.

The brown sandstones, No. 7, are here abnormally thickened at the expense of the variegated sandstones, No. 6. This may be due to the southward extension of the Echo Cliffs displacement, and a dike less than 2 feet thick and nearly vertical was seen on the south side of the valley running through the entire bluff and trending southwest almost exactly in line with Echo Cliffs.

SECTION III.—THE LOWER LITTLE COLORADO VALLEY.

[Pl. IV, E–F.]

This section aims to give the entire series from its contact with the Paleozoic near Black Tank, at the foot of San Francisco Mountain, to the highest beds reached on the mesas that rise to the south of the Moencopie Wash. It passes through the bed of the Little Colorado a few miles above Tanners Crossing and the important marl butte region to the east of the river, in which most of our work was done, and passes over the high escarpment 10 miles farther east, terminating in the white sandstones.

It has a length of 44 miles and embraces all the phases of each of the subdivisions of the system. It is therefore the principal section of the lower Little Colorado Valley.

Description of the section shown in fig. 3.

	Feet.
1. Carboniferous limestone (thickness unknown).	
2. Moencopie formation	500
3. Lithodendron member	600
4. Variegated marls	400
5. Sandstone ledge	100
6. Limestones and mortar beds	200
7. Variegated sandstones	800
8. Brown sandstones	300
9. White sandstones	100
Total thickness	3,000

SECTION IV.—WINSLOW.

[Pl. IV, G–H.]

This section begins with the canyon of Clear Creek, which is formed by heavy Carboniferous sandstone beds. It passes through the town of Winslow and crosses the Little Colorado just above old Brigham City, goes through Sunset, and follows nearly the line of the old trail from Sunset to Keams Canyon, passing near Pottery Hill, Chimney Butte, Castle Butte, the Moqui Buttes, Comar Spring, and Jettyto Spring. It therefore embraces considerable of the overlying Cretaceous and other later formations, the Trias extending some distance north of the southern boundary line of the Navajo Reservation.

Description of the section shown in fig. 4.

	Feet.
1. Carboniferous sandstone (thickness unknown).	
2. Moencopie formation	500
3. Lithodendron member	700
4. Variegated marls	400
5. Limestones and mortar beds	300
6. Variegated sandstones	800
7. Brown and white sandstones	300
	3,000
8. Cretaceous lignite bed	50
9. Cretaceous	750
Total thickness	3,800

No. 8 is variable and No. 9 is estimated.

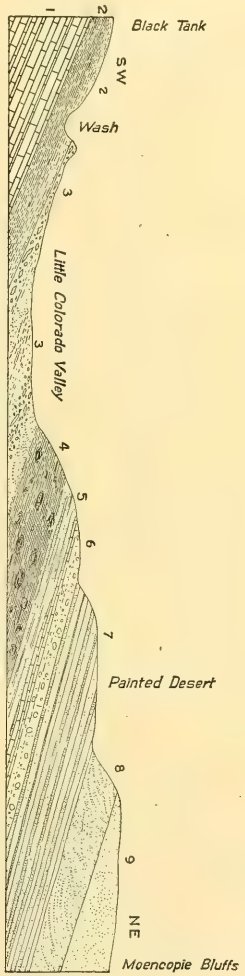

FIG. 3.—Section of the lower Little Colorado Valley, Arizona.

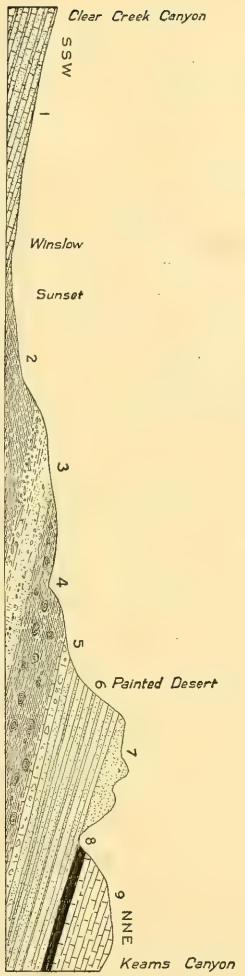

FIG. 4.—Section through Winslow, Sunset, and along the old trail from Sunset to Keams Canyon, Arizona.

SECTION V.—LEROUX WASH.

[Pl. IV, I–K.]

This section begins on the left bank of the river about 5 miles above Obed, opposite St. Joseph. The Carboniferous sandstones here come down to the river bed. It passes over the ridge below the mouth of Leroux Wash and follows the eastern slope of the wash for a distance of 20 miles, passing through the great amphitheaters of variegated marl buttes that I have described as constituting the greatest development that this formation attains. The section finally cuts across the upper portion of the wash and passes up the slopes beyond to a distance of 40 miles from the river, where the mesas attain an elevation of over 6,000 feet above the sea. It embraces practically the whole of the Trias.

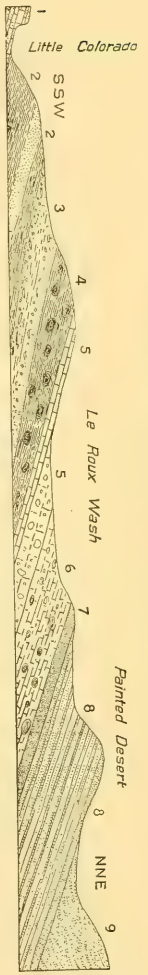

FIG. 5.—Section near Leroux Wash, Arizona.

Description of the section shown in fig. 5.

	Feet.
1. Carboniferous sandstone (thickness unknown).	
2. Moencopie formation	500
3. Lithodendron member	700
4. Variegated marls	400
5. Limestones and mortar beds	300
6. Calcareous marls	200
7. Orange-red sandstones	100
8. Variegated sandstones	700
9. Brown sandstones	200
Total thickness	3,100

SECTION VI.—THE PETRIFIED FOREST.

[Pl. IV, L–M.]

I have carried this section as far back on the southwestern slope of the Little Colorado as I was able to find any traces of the saliferous beds. The Carboniferous sandstone occupies the northeastern slope of the Pink Cliffs, and the section starts at an elevation above the sea of nearly 6,000 feet. It passes through Woodruff Butte, which is on the bank of the river, and thence on through the Petrified Forest and over the mesa on which the Natural Bridge is situated. I have

then carried it on a distance of 16 miles farther and let it terminate at the summit of the Shinarump, at an elevation of about 6,000 feet above the sea.

Description of the section shown in fig. 6.

	Feet.
1. Carboniferous sandstone (thickness unknown).	
2. Moencopie formation	500
3. Lithodendron member	800
4. Variegated marls	400
5. Limestones and mortar beds	200
6. Calcereous marls	100
Total thickness	2,000

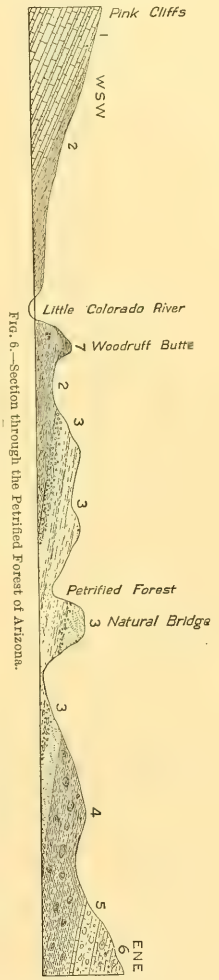

FIG. 6.—Section through the Petrified Forest of Arizona.

SECTION VII.—RED BUTTE.

[Pl. IV, N–O.]

This section needs no description. I have given it a length of 7 miles in order to embrace the lower slopes of the butte. These are much lower on the southwest side and ultimately terminate in the valley of one of the branches of Cataract Wash, which becomes a limestone canyon.

Description of the section shown in fig. 7 (p. 44).

	Feet.
1. Carboniferous limestone (thickness unknown).	
2. Argillaceous shales	75
3. Calcareous shales and limestones	100
4. Argillaceous shales	200
5. Sandstones	100
6. Argillaceous shales	125
Total thickness of the Moencopie formation	600
7. Sandstones	50
8. Shales	100
9. Conglomerates and cross-bedded sandstones	60
Total thickness of the Shinarump	210
10. Trap	125
Total height of butte	935

SECTION VIII.—THE GEOLOGICAL COLUMN.

In the following section I have given the maximum thickness of all the beds, which brings the total thickness up to 3,500 feet.

Description of the section shown in fig. 8.

	Feet.
1. Argillaceous shales	100
2. Calcareous shales	100
3. Argillaceous shales	200
4. Sandstones	100
5. Argillaceous shales	200
Total thickness of Moencopie formation	700
6. Lithodendron member	800
7. Variegated marls	400
8. Sandstones	100
9. Limestone ledge	20
10. Mortar beds	80
11. Calcareous marls	200
Total thickness of the Shinarump formation	1,600
12. Orange-red sandstone	100
13. Variegated sandstones	800
14. Brown sandstones	200
15. White sandstones	100
Total thickness of Painted Desert formation	1,200
Total thickness	3,500

In order that the geographical relations of the area included in the above discussion may be seen as clearly as possible, I present a sketch

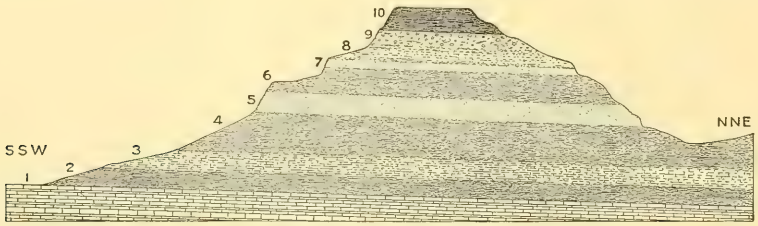

FIG. 7.—Section of Red Butte (see p. 43).

map (Pl. IV, in Part II) covering the territory in question and extending a little beyond the extreme limits of all the sections. Although originally formed by putting together the several sheets of the topographic map used in the work, the topography does not appear in the map, but

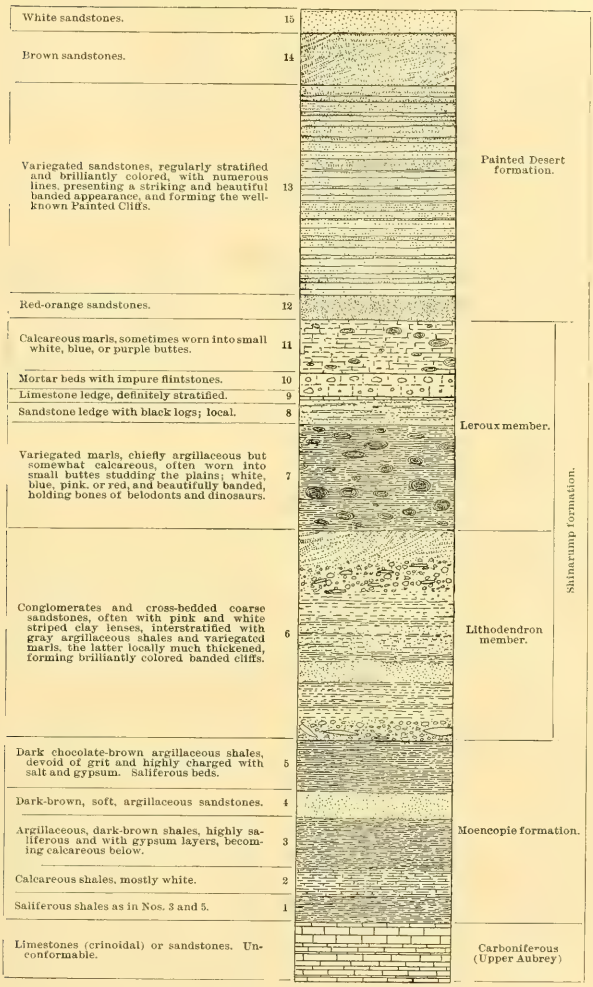

FIG. 8.—Geological column of the Older Mesozoic of Arizona.

the drainage and all the principal localities are shown and the lines of the sections indicated as follows:

A–B, Section I: Canyon of the Little Colorado.
C–D, Section II: The Moencopie Wash.
E–F, Section III: The lower Little Colorado Valley.
G–H, Section IV: Winslow.
I–K, Section V: The Leroux Wash.
L–M, Section VI: The Petrified Forest .
N–O, Section VII: Red Butte.
P–Q, Approximate line of strike.

PART II.

THE JURASSIC FLORA (CONTINUED).

THE JURASSIC FLORA OF OREGON.

A sufficiently full account of the expedition made in 1899 to the Buck Mountain region of Oregon, as also of previous studies of and collections made in that region, was given in the first paper.[a] As stated there, all the specimens that had ever been sent to Washington, including our large collection of that season, and the collections made by Mr. Storrs during previous years, were sent to Professor Fontaine for elaboration, and their study had been begun by him before that paper went to press.

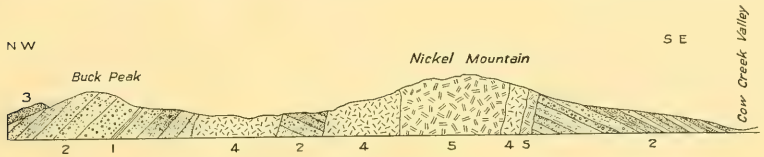

FIG. 9.—Section of Cow Creek, Nickel Mountain, and Buck Peak, Douglas County, Oreg.

It was completed in the spring of 1901, and Professor Fontaine's report, including descriptions of the species and careful indications relative to the illustrations, was sent on in April. The types have now all been figured, a new process (the Williams process) having been employed. It therefore only remained for me to prepare the report for publication. The following paper is essentially the report of Professor Fontaine, only, as in former cases, it has been necessary for me to prepare the synonymy of the previously described species and attend to the systematic arrangement. This, therefore, and a few footnotes, to which my initials are attached, are the only parts for which I am responsible. The accompanying sketch map of the region and section, prepared by Mr. J. S. Diller, will make the geographical and stratigraphical relations clear. (See Pl. V.)

[a] Twentieth Ann. Rep. U. S. Geol. Survey, Pt. II, 1900, pp. 368–377.

THE JURASSIC FLORA OF DOUGLAS COUNTY, OREG

By William M. Fontaine.

The plants described in this paper were obtained from strata that occur in Douglas County, Oreg., on or in the vicinity of Buck Mountain. Some fossils were originally discovered by Mr. Aurelius Todd, in 1872, at a locality about 300 feet below the summit of Buck Mountain, which has subsequently been named Todds Gulch. Since that time additional collections have been made both at that locality and at others discovered since the original find of Mr. Todd. The new localities occur north of the mountain on its slopes, and south of it in the vicinity of Nichols station.

Professor Ward has given an account of the discovery of the different localities, and also of the stratigraphical investigations made by Mr. Diller and Mr. Brown, at the time that the last and largest collections were made by himself, aided by Mr. Storrs. This account will be found in the first paper.[a]

From the facts given in that paper and in a letter from Professor Ward, and also from a few notes kindly furnished by Mr. Diller, the details that follow, regarding the position of the plant localities and their geological relations to one another, are obtained. The study of the geological relations of the strata containing the plants was carried far enough to show that, from the most northern to the most southern localities showing plants, they are continuous and form one group. At remote points, however, the exact stratigraphic relations of the plant-bearing beds were not made out, so that it can not be stated whether or not they are the same.

Buck Mountain is about 8 miles due west of the town of Riddles. It is about 3,500 feet above sea level, and rises 2,000 feet above the streams that flow along its base. On its west side, flowing north, is Olalla Creek. A branch of this creek flows westward along the northern base of the mountain, and is locally called Thompson Creek, but on the Land Office map it is named Hunter Creek. The plant-bearing strata are exposed on Thompson Creek, and at several spots collections were made from them. The strata on the creek dip toward the west at an angle of from 35° to 40°, and have a strike of N. 15° to 20° E. In passing south, however, into

[a] Twentieth Ann. Rep. U. S. Geol. Survey, Pt. II, 1900, pp. 368–377.

Buck Mountain, the strike varies considerably. It is not stated how much of the mountain is composed of these beds, but the highest of them occur about 300 feet below its top, where they are overlain by a heavy conglomerate of Lower Cretaceous age. Here the first discovery of the fossils was made by Mr. Todd. Plants were found in the strata in Buck Mountain at least 30 feet below Todd's original locality.

On Thompson Creek the plant beds are flanked to the east by a thick mass of sandstones and conglomerates of unknown age, which dip under them. Still farther east this last-named group is bounded by a belt of igneous rocks, to the east of which lies a belt of sandstones which contains invertebrate fossils of Lower Cretaceous age. These sandstones dip westward, as if lying under the plant beds. They may be dropped in this position by a dislocation. The sandstones are bounded on the east by a great mass of serpentine. At the western end of the section, on Thompson Creek, the Lower Cretaceous conglomerate, which overlies the plant beds in the top of Buck Mountain, is absent, it having been removed by erosion before the deposition of the Eocene. This last immediately overlies the plant beds.

Professor Ward states that on Thompson Creek, the first of the group now in question that was found to contain plant fossils, is a slate that lies to the west of the sandstone and conglomerate mass of unknown age above mentioned. This occurs nearly due north of Buck Mountain. This is stratigraphically the lowest plant bed on the creek. The stratum with plants is only a few feet thick. This for distinction I shall call plant bed No. 1. It is overlain by conglomerates 50 feet or more in thickness. The conglomerate has overlying it another bed of slate similar in general appearance to the first. This also contains plants and yielded much the larger part of the specimens collected there. It may be called plant bed No. 2. In the vertical section it is about 75 feet above bed No. 1. This seems to be the highest bed geologically from which collections were made on Thompson Creek. The upper slate is overlain a short distance to the west by Eocene beds.

Mr. Diller and Mr. Brown followed the group containing the plants southward into Buck Mountain, proving the identity of the plant beds of that mountain with those on Thompson Creek. From the mountain the strata were followed southward to the vicinity of Nichols station, where

the most southerly collections were made. Nichols station is on the Southern Pacific Railroad, 7 miles due south of the Thompson Creek plant beds, and the plant localities near this station lie in a north-south line that passes through those on Buck Mountain and ends with the localities on Thompson Creek. The geology of the region near Nichols station is more complicated than that of Thompson Creek, and, as will be seen from the statement that follows, there would seem to be some change in the rock character.

Mr. Will Q. Brown first discovered plants in the railroad cut near the whistling post for the station, and made a small collection. Professor Ward says, in speaking of his visit to this locality, that "very little additional to Mr Brown's collection was found in the railroad cutting." It was seen however, that the same slates occur here as in the Buck Mountain district and that they came from the north in a regular way. At this point the course of Cow Creek is nearly along the strike of the slates, and they cross the creek very obliquely and follow the bed of the stream for some distance, giving an exposure that permitted a large collection to be made. The points of difference from the exposures farther north are these: The slates near Nichols station are nearly vertical and have a high dip to the east instead of dipping westerly, as on Thompson Creek. They have a thickness of about 200 feet and show no conglomerate bands. As there had been no continuous tracing of the strata from Buck Mountain to this locality, the stratigraphical work does not show whether or not the plant beds here are identical with those on Thompson Creek.

From the preceding statements it will be seen that the plants described in this paper come from three regions separated by intervals in which no plants were collected. The Thompson Creek region is separated from the Buck Mountain localities by a comparatively short interval, while the Nichols station localities are much more remote. The collections made at the different spots, at different times and by different persons, are of very unequal value, for they range from only one or two specimens in some cases to hundreds in others. This fact should be borne in mind in noting the distribution of the plants. The absence of a given plant from a particular locality may mean, not that it was really absent, but that the collector failed to obtain it in his imperfect search. In order that some idea may be had of the great difference in the size of these collections I will give a brief account of them, stating the localities from which they

were obtained. For convenience of reference the localities will be numbered and the reference of the different fossils to them will be by these numbers. In the case of some collections the specimens were counted. In other cases the number must be indicated in some other way and estimated. The following are the localities:

Locality No. 1.—This is Todd's first discovered locality. It is on the east side of Buck Mountain, 300 feet below the top. Of Mr. Todd's collections only 3 specimens are among those available for examination. From this locality Mr. Storrs subsequently collected, in September, 1897, about 50 specimens, and still later Professor Ward and Mr. Storrs obtained 25 specimens.

Locality No. 2.—This locality occurs on Thompson Creek, at the northern foot of Buck Mountain, near the dam of the Day Hydraulic Gold Mining Company. From this locality Mr. Storrs, in the fall of 1896, obtained a small collection of about 30 specimens, and on June 30, 1897, he made here a somewhat larger collection of about 50 specimens. In September, 1897, Mr. Storrs obtained from the same locality about 70 specimens. These plants come from the lower slate bed, bed No. 1, mentioned above. Some of the following collections, made later by Professor Ward and Mr. Storrs in this region, may have been obtained from the spots at which Mr. Storrs had previously collected.

Locality No. 3.—This is in a ravine at the foot of Buck Mountain on the right bank of Thompson Creek immediately below the Day hydraulic dam. Only 1 specimen was collected here by Mr. Storrs, on September 12, 1899.

Locality No. 4.—This is 200 yards farther down, or to the southeast of locality No. 3, in a ledge on the right bank of the same stream. Here, on September 14, 1899, Professor Ward collected nearly 100 specimens.

Locality No. 5.—This is on the left bank of Thompson Creek, on the western slope of a ravine coming from the south and 300 yards below the Day hydraulic dam. Professor Ward collected here, on September 12, 1899, 15 specimens.

Locality No. 6.—This is 100 yards southwest of locality No. 5, in a low ledge on the left bank of Thompson Creek. Professor Ward collected here, on September 14, 1899, about 40 specimens and small fragments.

Locality No. 7.—This occurs in the bed of Thompson Creek, in the right bank, beginning nearly opposite to locality No. 6, but extending some 50 feet along the stream. Professor Ward and Mr. Storrs collected here, September 12–14, 1899, several hundred fine specimens. This is decidedly the largest collection made. It much surpasses the other collections in the size of the specimens and in the perfection of the plants. The plants collected here and at locality No. 6, come from the slates above the conglomerate.

Locality No. 8.—This occurs 200 yards east of locality No. 2. Mr. Storrs collected here, in September, 1897, about 10 specimens.[a]

[a] He seems to have exhausted the locality, as no plants could be found there, even by him, in 1899. He said that his specimens came from one bowlder which he broke up.—L. F. W.

Locality No. 9.—This is 200 yards northwest of locality No. 1. Diller and Brown collected here, on September 13, 1899, only 1 specimen.

Locality No. 10.—This is situated one-third of a mile northwest of locality No. 1. Diller and Brown collected here, on September 13, 1899, only 1 specimen.

Locality No. 11.—This is a gulch called by the collectors "Ginkgo Gulch." It is on the slope of Buck Mountain, northwest of locality No. 1. Diller and Brown collected here, on September 13, 1899, 2 specimens (counterparts), with impressions of a Ginkgo.

Locality No. 12.—This is on the main spur running north from Buck Peak, in strata (Jurassic) close to the Lower Cretaceous. Mr. Diller collected here, on September 14, 1899, 5 small specimens.

Locality No. 13.—This is in the next gulch north of Todds Gulch, at about the same altitude as locality No. 1, and it is perhaps the same locality as No. 9. Mr. Storrs collected here, on September 15, 1899, 5 specimens and several fragments.

Locality No. 14.—This is on Thompson Creek, one-fourth of a mile above locality No. 2. Mr. Storrs collected here, on October 25, 1897, about 25 specimens. The rock here is much like that of locality No. 7, and splits well.

Locality No. 15.—This is on Seven Spring Ridge, a mile east of Buck Peak, and one-half mile east-southeast of locality No. 1. Professor Ward and Mr. Storrs collected here, on September 15, 1899, 13 specimens.

Locality No. 16.—This is in Todds Gulch, 20 feet below locality No. 1. Professor Ward and Mr. Storrs collected here, on September 15, 1899, 14 specimens.

Locality No. 17.—This is in Todds Gulch, 30 feet below locality No. 1. Professor Ward and Mr. Storrs collected here, on September 15, 1899, over 100 specimens.

Locality No. 18.—This is in a railroad cut near the whistling post, half a mile north of Nichols station. Here Mr. Will Q. Brown collected about 30 specimens, and Mr. Claude Rice obtained, at another time, 2 specimens. Later, on September 17, 1899, Professor Ward and Mr. Storrs collected at this spot over 100 small specimens.

Locality No. 19.—This is in the bed of Cow Creek, on the right bank, one-half to three-fourths of a mile north of Nichols station. The locality contains the continuation of the slates that yielded the plants in the railroad cutting. They are here much better exposed. From these slates Professor Ward and Mr. Diller, and Messrs. Storrs and Brown collected, on September 18 and 19, 1899, several hundred specimens. This collection is not so large or so fine as that made at locality No. 7, but much surpasses any of the others.

Locality No. 20.—This is in the bed of Thompson Creek, a little east of north of Buck Peak, on Josten's ranch, at the spot where parties camp. This is quite unimportant, as Mr. Brown collected here, in 1898, 2 specimens only, showing faint traces of a plant.

From this account of the localities and the collections made at them it will be seen that localities Nos. 3, 9, 10, 11, and 20 afford such small collections that they are unimportant. They show nothing that indicates

an age different from that of the localities from which larger collections were made.

In estimating the fitness of these collections to give an idea of the flora of the time in which the slates were deposited, we must bear in mind that we can not judge from the mere number of specimens. The later collections, which are by far the largest, were made under Professor Ward's supervision, and in part by himself. From this cause the collections contain a much larger proportion of specimens showing different plants and significant parts of plants than they would contain if made by one unacquainted with fossil botany. In the latter case a large percentage of the specimens are duplicates that throw no additional light on the character of the plant or else are very vague impressions that can not be determined.

DESCRIPTIONS OF THE SPECIES.

Phylum BRYOPHYTA.[a]

Class HEPATICÆ.

Order MARCHANTIALES.

Family MARCHANTIACEÆ.

Genus MARCHANTITES Brongniart.

MARCHANTITES ERECTUS (Bean) Seward?[b]

Pl. VI, Figs. 1, 2.

1864. *Fucoides erectus* Bean in Leckenby: Quar. Journ. Geol. Soc. London, Vol. XX, p. 81, pl. xi, figs. 3a, 3b (erroneously numbered 2a, 2b on the plate).

1869. *Haliseris erectus* (Bean) Schimp.: Pal. Vég., Vol. I, p. 185.

1898. *Marchantites erectus* (Bean) Sew.: Fossil Plants for Students of Botany and Geology, p. 233, fig. 49 on p. 233.

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[a] I shall follow, as nearly as practicable, in this paper the system of Adolph Engler, as contained in Die natürlichen Pflanzenfamilien of Engler and Prantl, continued by Engler since the death of Prantl, and perfected in the latest edition of his Syllabus. The names of the several groups, however, will not be in all cases those of Engler, but will conform to the new Code of Botanical Nomenclature adopted by American botanists and published in May, 1904. In my first paper the Bryophyta, Pteridophyta, and Spermatophyta were called subkingdoms of the vegetable kingdom in general. The American code proposes the term "phylum" for these, conforming to zoological usage.—L. F. W.

[b] Mr. Seward, in his Jurassic Flora of the Yorkshire Coast, p. 49, includes in the synonymy of this species, without questioning them, the *Fucoides arcuatus* of Lindley and Hutton, published in 1837, and the *Sphærococcites arcuatus*, which was the name given to this form by Presl in 1838, and takes up for a specific name the *Fucoides erectus* of Bean, figured by Leckenby in 1864. If the *Fucoides arcuatus* is the same as the

Leckenby has described from the Scarborough Oolites, as *Fucoides erectus*,[a] a singular plant that resembles one found in a single specimen at locality No. 18. Owing to the small amount of material, this can not be certainly identified with Leckenby's fossil. Seward has given Leckenby's plant the name *Marchantites erectus*.[b] The Oregon fossil shows only the imprint, no plant matter being preserved. It is composed of a rather flexuous stem, apparently once cylindrical in form, that sends off obliquely and sparingly short stout branches that have obtuse ends. The branches maintain their width to their ends and are nearly as strong as the axis from which they are sent off. In the main stem, if it can be called such, and in each branch, there is a single flexuous nerve quite distinctly shown. On the stem and branches there is a vague reticulation on each side of the midnerve, which appears to be caused by depressed areas. In the center of the depressed areas there is apparently a small prominence, possibly due to a sorus. Leckenby describes his plant as having a midnerve in each branch, on each side of which there is a fructification composed of one or more rows of ovate vesicles immersed in the frond. The mode of branching of the Oregon fossil differs from that of Leckenby in being not so palmate. It is similar to that of Brachyphyllum and the plant may be really a twig of that conifer.

Phylum PTERIDOPHYTA (Ferns and Fern Allies).[c]

Order FILICALES.

Ferns.—Ferns are not rare at some of the localities and they show a decided difference in distribution, for in some places they are almost entirely wanting, being most deficient where the cycad remains are most

F. erectus, the combination should have, by the rules of nomenclature, the earlier specific name. In his discussion, however, on the next page, after examining both the types, he says that "the specimen to which Lindley and Hutton applied the latter name was much more imperfect than Leckenby's type, and it is not certain, though highly probable, that the two are specifically identical."

I have not thought best, therefore, to change the combination, but the only logical way to escape from the difficulty is to omit the doubtful name entirely from the synonymy, which I have done.—L. F. W.

[a] On the sandstones and shales of the Oolites of Scarborough, etc., by John Leckenby: Quart. Journ. Geol. Soc. London, Vol. XX, 1864, p. 31, pl. xi, figs. 3a, 3b.

[b] In his Yorkshire Flora, 1900, he redescribes the species on p. 49 and reproduces on p. 50, fig. 2, the figure cited from his Fossil Plants in the above synonymy; which is from Bean's type specimen in the Woodwardian Museum represented by Leckenby in his fig. 3a. He finds, however, in the British Museum of Natural History at South Kensington another specimen (No. V. 3652) which he figures on pl. xix, fig. 2, of his Yorkshire Flora (see p. 51).—L. F. W.

[c] See footnote to Bryophyta, p. 53.

abundant. The specimens are generally very fragmentary, and, what is noteworthy, the parts preserved are often in a good state of preservation in that the epidermal tissue is intact, and the plant substance gives a black carbonaceous film on the rock. The parts do not seem to have suffered much from maceration due to long floating in water, hence the fragmentary state must be produced by some other cause. The coniferous fossils also show a great comminution of parts, with a good preservation of the plant substance. The cycads do not show so extensive a laceration, although they, too, are much broken, while the parts that are shown are wonderfully well preserved.

Family CYATHEACEÆ.[a]

Genus DICKSONIA L'Héritier.

DICKSONIA OREGONENSIS Fontaine n. sp.

Pl. VI, Figs. 3–9; Pl. VII.

1898. *Dryopteris monocarpa* (Font.) Kn.: Bull. U. S. Geol. Surv., No. 152, p. 92.
1900. *Dryopteris monocarpa* (Font.) Kn. Ward: Twentieth Ann. Rep. U. S. Geol. Surv., 1898–99, Pt. II, p. 369.

This plant was probably arborescent. Both fertile and sterile forms were obtained. Most of the specimens show fertile forms. The largest specimens seen with attached pinnæ give no more than a tripinnate division but these were evidently fragments of much larger compound pinnæ. Fragments of a rachis not showing attached pinnæ, but so associated with this fern as to indicate clearly that they belong to it, were obtained that are 8 mm. wide. The ultimate pinnæ are very short, not surpassing 45 mm. in length. The pinnules with entire margins, such as are found in the upper portion of the compound pinnæ and in terminal parts of the subordinate pinnæ, are quite small, being not more than 3–4 mm. long and 2–3 mm. wide. They are narrowed toward the base and elliptical in form. They are attached by this narrowed base so as to make a small angle with the rachis, and are decurrent, forming a very narrow wing. The basal pinnule on the upper side of the ultimate pinna is larger than the rest and is more incised, having undulate or dentate margins

[a] When my first paper was written the part of Engler and Prantl's system containing the Pteridophyta was as yet unpublished. It has since been completed, and their subdivisions into families will be followed in the present paper.—L. F. W.

when the remaining pinnules are entire. The degree of union of the pinnules depends upon their position, they being more united and passing into lobes in terminal parts. In the opposite direction and lower in the compound pinnæ they are more incised. In passing to lower portions the entire pinnules pass through those with undulate margins into those with dentate and lobed margins, and finally into ultimate pinnæ, the lobes becoming pinnules. The tips of the pinnules range from acute forms in the entire ones to subacute or obtuse ones in the incised pinnules. The leaf substance must have been thick and leather-like, with an epidermis that was very dense and durable, for much of the plant matter is often preserved, giving a shining film on the rock. The nerves are those of Cladophlebis. In the entire pinnules there is a midnerve set on obliquely. This splits up into branches toward the end. One or more branches may be given off very obliquely from the sides of the midnerve. These may be forked if they are basal nerves, but are mostly single.

The sori, in proportion to the size of the pinnules and lobes, are very large. Many of the specimens present the lower surface of the foliage uppermost, so that the sori are well shown, and in many cases they are remarkably well preserved. They are placed within the margin and are attached to the end of one of the lateral nerves. In the case of the entire pinnules there is only one sorus, and this is on the end of the lateral nerve given off from the base of the midnerve on its upper side. The sorus is so large that it covers most of the surface of the anterior base of the pinnule. The pinnules with dentate or lobed margins have a sorus for each tooth or lobe placed on the ends of lateral nerves and covering the anterior portion of the tooth or lobe. Often nothing but these large sori can be seen in such pinnules, and by their position they outline the form of the pinnule.

The sori are covered by a thick durable indusium, which is apparently inserted under them. The sori stand out strongly convex and leave deep pits in the rock. They are globular in form, with a slight elongation. Owing to distortion they vary a good deal in their present form. When, however, the specimens present the upper surface uppermost, so that the sori must be seen through the lamina, they appear much smaller and are punctiform elevations.

The fructification as made out is near enough to that of Dicksonia to justify placing the plant in that group.

To judge from the specimens, the plant shows a marked tendency to fructification, for most of them are fertile parts. It is probably a new species. The sterile entire pinnules resemble those of Heer's *Dicksonia gracilis*,[a] from the Jurassic of Asia, but the ultimate pinnæ are shorter, and Heer's plant lacks the heteromorphous feature in the pinnules.

Heer calls attention to the resemblance of his plant to the *Scleropteris Pomelii* of Saporta, from the Jurassic of France. This resemblance exists, but it is not sufficient to justify identifying the Oregon form with Saporta's fossil. No fructification exists on either of these previously described fossils, and in view of the predominance of it in the Oregon fossils it is not likely that it would be wanting in the former if they are identical with the latter. In shape and size the sori of *Dicksonia oregonensis* agree pretty well with those of Heer's *Dicksonia clavipes*,[b] from the Jurassic of Siberia, but the fertile pinnules are not, as in that plant, contracted to stalks. So many specimens of the plant now in question were obtained that a pretty full representation of it may be given by selecting parts from different positions on the compound pinnæ. This is necessary because of the small size of the fragments that are preserved.

Pl. VI, Fig. 3, represents a portion of a penultimate pinna with several attached ultimate pinnæ, as well as several unattached ones, that apparently were once attached. This is the only specimen in hand that is credited to Mr. Todd's collections. It presents the upper surface of the plant uppermost and shows the sori as they appear in such a case. When this specimen was the only one available, I was led to regard it as *Aspidium monocarpum*, a fern found in the Lower Cretaceous of Great Falls, Mont. This is the specimen referred to as *Dryopteris monocarpa* by Professor Ward in the paper quoted above (p. 369).[c] Specimens showing the same character are not uncommon in the collections made since that of Mr. Todd, and they show that the plant is *Dicksonia oregonensis*. Pl. VI, Fig. 4, shows a single pinnule

[a] Flor. Foss. Arct., Vol. IV, Pt. II (Beiträge zur Jura-Flora Ostsibiriens und des Amurlandes), p. 92, pl. xvii, fig. 3.

[b] Op. cit., pp. 33–34, pl. ii, fig. 7.

[c] The genus name Dryopteris (Adanson, 1763) has priority over Aspidium (Swartz, 1800) by twenty-seven years. Dr. Knowlton referred Professor Fontaine's species (*monocarpa*) to the former genus in his Catalogue of the Cretaceous and Tertiary Plants of North America (Bull. U. S. Geol. Survey No. 152, 1898), p. 92.—L. F. W.

enlarged. Fig. 5 gives terminal portions of two penultimate pinnæ carrying sterile pinnules, with entire margins (entire pinnules), and hence they come probably from high up on the compound pinna. Pl. VI, Figs. 6 and 7, represent magnified pinnules to show details. Pl. VI, Fig. 8, represents portions of penultimate pinnæ, with fertile entire and dentate pinnules, that probably nearly correspond in position with the sterile parts given in Fig. 5. Pl. VI, Fig. 9, shows an enlarged pinnule of Fig. 8 with sori. Pl. VII, Fig. 1, gives a portion of a penultimate pinna with ultimate pinnæ carrying sterile pinnules having crenately dentate margins. These pinnules are distorted somewhat by being pressed down into the rock. Pl. VII, Fig. 2, shows a fragment of a penultimate pinna carrying ultimate pinnæ having very small fertile pinnules with crenate margins. This presents the upper surface of the plant uppermost, so that the sori are seen through the leaf substance. Pl. VII, Fig. 3, shows an enlarged pinnule of Fig. 2. Pl. VII, Fig. 4, gives a fragment of a penultimate pinna with portions of ultimate pinnæ carrying sterile lobed pinnules from pretty low down on the compound pinna. These are of the largest size, being lobed and tending to pass into ultimate pinnæ. Pl. VII, Fig. 5, shows a fragment of a penultimate pinna with ultimate pinnæ having sterile pinnules from a position still lower than the part shown in Fig. 4. The lobes have here become pinnules. This specimen is distorted from pressure. Pl. VII, Fig. 6, represents an ultimate pinna magnified two diameters to show the heteromorphous basal pinnules. Pl. VII, Fig. 7, gives an entire sterile pinnule magnified similarly to show the nerves. Pl. VII, Fig. 8, gives a dentate sterile pinnule with the same enlargement. Pl. VII, Fig. 9, gives, with the same enlargement, a fertile entire pinnule to show the sorus. Pl. VII, Fig. 10, gives, with slightly greater enlargement, a lobed fertile fragment to show the sorus.

The species occurs most abundantly at locality No. 2, but is common also at No. 3. It is found also at Nos. 1, 4, 5, 6, 7, 16, and 17.

Dicksonia oregonensis is the most abundant of the Oregon Jurassic ferns and is found at more localities than any of the others. The different parts show a considerable variation in appearance, as is to be seen in the figures. Before a close comparative study of the different forms had been made I was inclined to think that several species were represented in them.

Genus CONIOPTERIS Brongniart.

CONIOPTERIS HYMENOPHYLLOIDES (Brongniart) Seward ?

Pl. VIII, Figs. 1–3.

1828. *Sphenopteris hymenophylloides* Brongn. [non Weiss]: Prodrome, pp. 51, 198 (nomen).
1829. *Sphenopteris hymenophylloides* Brongn. [non Weiss]: Hist. Foss., Vol. I, p. 189, pl. lvi, figs. 4a, 4b.
1829. *Sphenopteris stipata* Phill.: Geology of Yorkshire, pp. 167, 190, pl. x, fig. 8.
1829. *Sphenopteris muscoides* Phill.: op. cit., pp. 167, 190, pl. x, fig. 10.
1835. *Sphenopteris arguta* L. & H.: Foss. Fl. Gt. Brit., Vol. III, p. 53, pl. clxviii.
1835. *Tympanophora simplex* L. & H.: op. cit., Vol. III, p. 57, pl. clxx, fig. A.
1835. *Tympanophora racemosa* L. & H.: op. cit., Vol. III, p. 58, pl. clxx, fig. B.
1836. *Hymenophyllites Phillipsii* Göpp.: Syst. Fil. Foss., p. 256.
1851. *Sphenopteris nephrocarpa* Bunb.: Quart. Journ. Geol. Soc. London, Vol. VII, p. 179, pl. xii, figs. 1a, 1b.
1865. *Dicksonia hymenophylloides* (Brongn.) Ett.: Farnkräuter der Jetztwelt, p. 217.
1865. *Hymenophyllites nephrocarpos* Zign.: Osserv. sulle Felci Foss. dell'Oolite, p. 22.
1872. *Sphenopteris Pellati* Sap.: Plantes Jurassiques, Vol. I, p. 278, pl. xxxvi, figs. 1, 1a, 1b.
1875. *Sphenopteris affinis* Phill. [non L. & H.]: Geology of Yorkshire, 3d ed., p. 213, lign. 30 on p. 213.
1875. *Sphenopteris dissocialis* Phill.: op. cit., p. 214, lign. 32 on p. 214.
1876. *Dicksonia clavipes* Heer: Fl. Foss. Arct., Vol. IV, Pt. II (Jura-Fl. Ostsibiriens), p. 33, pl. ii, figs. 7, 7b.
1876. *Thyrsopteris Maakiana* Heer: Fl. Foss. Arct., Vol. IV, Pt. II (Jura-Fl. Ostsibiriens, etc.), p. 31, pl. i, figs. 1a, 1b, 2, 2c, 2d, 3b; pl. ii, figs. 5, 5b, 6.
1889. *Dicksonia nephrocarpa* (Bunb.) Yok.: Journ. Coll. Sci. Imp. Univ. Japan, Vol. III, Pt. I, p. 25, pl. i, figs. 1, 1a.
1890. *Dicksonia Heerii* Rac.: Bull. Int. Acad. Sci. de Cracovie, janvier, 1890, p. 32 (nomen).
1890. *Dicksonia Zarecznyi* Rac.: loc. cit. (nomen).
1894. *Dicksonia (Eudicksonia) Heerii* Rac.: Flora Kopalna (Pamietnik Wydz. mat. przyr., Vol. XVIII), p. 174 [32], pl. x, figs. 5, 6a, 7–10, 11a, 12–14.
1894. *Dicksonia Zarecznyi* Rac.: op. cit., p. 175 [33], pl. ix, fig. 12; pl. xii, figs. 7–16; pl. xiv, fig. 17.
1900. *Dicksonites clavipes* (Heer) Sew.: Manchester Memoirs, Vol. XLIV, No. 8, p. 6.
1900. *Thyrsopteris Maakiana* Heer ? Font.: Twentieth Ann. Rep. U. S. Geol. Surv., 1898–99, Pt. II, p. 343, pl. xlix, fig. 1.

1900. *Coniopteris hymenophylloides* (Brongn.) Sew.: Jur. Fl. Yorksh. Coast, p. 98, pl. xvi, figs. 4–6; pl. xvii, figs. 3, 6–8; pl. xx, figs. 1, 2; pl. xxi, figs. 1–3, 3a, 4, 4a.

A small Sphenopteris-like fern, with fructification, was found at locality No. 19. In the shape of its pinnules it much resembles some of the sphenopterid forms from the Lower Oolite of Yorkshire. Seward,[a] in his paper on the plants of the Manchester Museum, gives good reasons for adopting the name Coniopteris for some of the sphenopterid forms of the Yorkshire Lower Oolite, and unites a number of them with his species *Coniopteris hymenophylloides*. In his recent work on the Yorkshire Fossil Plants he gives a number of figures of this species. Some of these agree so well with the Oregon fossil now in question that I have no doubt that it is the same species with the English one. As, however, the amount of material is so small, I do not positively identify it as such.

The Oregon fossil occurs in only one specimen in counterparts. This shows a small fragment of a penultimate pinna, having several ultimate ones that are nearly entire. The plant is beautifully preserved. The leaf substance is very thick and it appears wrinkled by the strong nerves and the sori. The ultimate pinnæ are very short, the longest being hardly 15 mm. long, while their entire expanse at base, the widest part, is only about 7 mm. The pinnules are minute, the largest basal ones being not more than about 4 mm. long and a little over 3 mm. wide. They vary a good deal in shape as well as in size, according to their position on the ultimate pinna. The rachis has a narrow wing from which the pinnules rise. On the upper side of the rachis the pinnules are larger than on the lower side. The basal pinnule on the upper side is larger than the others on that side. This larger pinnule is subquadrate in form. The others on the same rachis become more rounded, elliptical, and even club-shaped toward the ends of the pinnæ. The pinnules on the lower side are all elliptical, passing to rounded and club-shaped forms. The subquadrate, and indeed all the pinnules, are attached by much narrowed bases. The lateral nerves in the larger pinnules are pinnately, but very obliquely, placed on the midrib. In the others there is a parent nerve.

[a] Notes on some Jurassic plants in the Manchester Museum: Manchester Memoirs, Vol. XLIV, No. 8, 1900, pp. 5–8.

Pl. VIII, Fig. 1, shows both counterparts natural size. Pl. VIII, Fig. 2, gives, enlarged, an upper basal pinnule, and Fig. 3 one from the terminal portion of the pinna.

Genus THYRSOPTERIS Kuntze.[a]

Thyrsopteris Murrayana (Brongniart) Heer.[b]

Pl. VIII, Figs. 4–11.

1836. *Pecopteris Murrayana* Brongn.: Hist. Vég. Foss., p. 358, pl. cxxvi, figs. 1, 1A, 2–4, 4A, 5, 5A.

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[a] Mr. Seward very naturally doubts the occurrence in a fossil state of a monotypic genus of ferns now living, but confined to the island of Juan Fernandez, and he thinks that the Cretaceous species belong to the extinct genus Onychiopsis of Yokohama and the Jurassic ones to Brongniart's Coniopteris. In the Fifteenth Annual Report of the United States Geological Survey, 1895, pp. 383–384, I discussed this question, referring to *Thyrsopteris Murrayana* (Brongn.) Heer from the Oolite of Yorkshire, saying:

"Brongniart had already pointed out the resemblance of his *Pecopteris Murrayana* from the Oolite of Yorkshire to this living genus, and had united this species with others into a distinct genus, Coniopteris, to which Saporta afterwards referred a number of species from the Jurassic of France. It is therefore very probable that the genus Thyrsopteris, which is now so nearly extinct, was widely distributed over the northern hemisphere in Jurassic time. We have in America no true Jurassic flora thus far, but should such a flora hereafter come to light there can scarcely be any doubt that this genus will be found in it."

This prediction seems now to have been verified. In the Nineteenth Annual Report, Pt. II, p. 658 (footnote), the question of retaining the name was again raised. Seward and Nathorst regard all the forms as belonging to extinct genera, but there is not complete harmony among paleobotanists on this point. Potonié in Engler and Prantl's Nat. Pflanzenfamilien, Teil I, Abth. 4, Lief. 188, Leipzig, 1899, p. 123, says: "The remains from the Jurassic of Spitzbergen, of the Amoor country, and of England, especially those figured by Leckenby (1864) and Heer (1876), including *Thyrsopteris Murrayana* (Brongn.) Heer, and *T. Maakiana* Heer, as well in their fertile as their sterile parts, so closely resemble the recent species *T. elegans* that it is difficult to doubt the correctness of their reference to that genus."

While, therefore, it is probable that all the fossil forms will ultimately be referred to extinct genera, such genera must have closely resembled Thyrsopteris and were probably its early Jurassic and Cretaceous ancestors. The present isolated species must therefore be regarded as a last remnant of a once widely diffused group of ferns, and belongs to the class of waning types, like *Ginkgo biloba* and the two surviving species of Sequoia. The case is therefore by no means an isolated one, and becomes highly interesting to the student of plant development.—L. F. W.

[b] Although Mr. Seward (Jur. Fl. Yorksh. Coast, p. 100) refers Heer's plant to *Coniopteris hymenophylloides*, Professor Fontaine sees reasons for keeping it distinct. After receiving Mr. Seward's book, I called his attention to the fact, and in a letter to me, dated August 21, 1901, he says:

"My idea was that only those forms of Murrayana type ought to be united with Coniopteris that have the proper fructification, or are closely associated with it. There is no such fructification with the Oregon forms. I think that the Murrayana type of fern is the sterile form of more than one Jurassic species, and it would be convenient to keep the name for any of that type whose fructification is not known, and use it as the name Cladophlebis is used. This was the reason why I retained the species."

I give therefore in the synonymy only those references that are confined to this form as found in Jurassic strata—i. e., to the original Yorkshire plant and to Heer's specimens from Ust-Balei in Siberia. The Liassic form *Pecopteris Pingelii* Schouw, *Dicksonia Pingelii* (Schouw) Bartholin, from the island of Bornholm, although thought by Brongniart to be perhaps the same, and generally so regarded by later authors, is omitted as of earlier date involving change of name, and as still somewhat doubtful, but as it has always been associated with *Pecopteris Murrayana* and not with *Sphenopteris hymenophylloides*, it is also omitted from the synonymy of *Coniopteris hymenophylloides*.—L. F. W.

1838. *Polystichites Murrayana* (Brongn.) Presl in Sternberg: Flora der Vorwelt, Vol. II, p. 117.

1849. *Coniopteris Murrayana* Brongn.: Tableau, p. 26.

1856. *Hymenophyllites Murrayana* (Brongn.) Zign.: Fl. Foss. Form. Oolith., Vol. I, p. 92.

1865. *Sphenopteris Murrayana* (Brongn.) Zign.: Osserv. sulle Felci Foss. dell'Oolite, p. 20.

1876. *Thyrsopteris Murrayana* (Brongn.) Heer: Fl. Foss. Arct., Vol. IV, Pt. II (Jura-Fl. Ostsibiriens), p. 30, pl. i, figs. 4, 4b, 4c; pl. ii, figs. 1, 2a, 3 (left side of fig.), 4, 4b; pl. viii, fig. 11b.

There are among the Oregon fossils certain imprints that have the aspect of Sphenopteris. They are mostly small and very poorly preserved, so that their true character can not always be made out. The leaf texture seems to have been very thin, so that the imprints of the pinnules are generally faint. The forms agree very well with the fern described by Heer as *Thyrsopteris Murrayana*,[a] and I identify the plant with that species. The pinnules are narrowed at base very much, so as to give them a marked sphenopterid habit. Above the narrowed base the larger ones are oval or oblong, with obtuse lobes or teeth that are very obliquely placed. The nerves of these were not seen. The smaller pinnules, from higher up on the compound pinna, are subrhomboid or subtriangular, with crenate or undulate margins. Their nerves consist of a flexuous midnerve sending off mostly single nerves. The lower anterior one may be forked. No fructification was found.

Pl. VIII, Fig. 4, gives the terminal portion of an ultimate pinna from probably low down on the compound pinna, carrying the larger sized pinnules. Figs. 5 and 6 show magnified pinnules of this. Fig. 7 represents the largest specimen found. It shows the rachis quite well, but the pinnules are indistinct. Fig. 8 is an enlarged portion of Fig. 7. Fig. 9 shows fragments of ultimate pinnæ, probably from high up on the compound pinna, and Figs. 10 and 11 two enlarged pinnules. This plant is quite variable in the form of its pinnules, if indeed all the specimens show forms belonging to the same species. In some cases a portion of the pinnules resembles the lower pinnules of Heer's *Dicksonia arctica*,[b] with undulate margins. Others could be selected that resemble more the pinnules of *Thyrsopteris Maakiana*[c] of the same

[a] Fl. Foss. Arct., Vol. IV, Pt. II, pp. 30–31, pl. ii, figs. 1–4.
[b] Op. cit., Vol. V, Pt. II (Beitr. z. Foss. Fl. Sibiriens), pp. 12–13, pl. iii, figs. 1–7.
[c] Op. cit., Vol. IV, Pt. II, pp. 31–32, pl. i, figs. 1–3; pl. ii, figs. 5, 6.

author. But as there is no good means of separating them, and as, on the whole, they agree better with *Thyrsopteris Murrayana*, I place them in that species.

The forms united under this species occur with several imprints at localities Nos. 2, 7, and 19.

Family POLYPODIACEÆ.

Genus POLYPODIUM Linnæus.

Polypodium oregonense Fontaine n. sp.

Pl. VIII, Figs. 12–15; Pl. IX; Pl. X, Figs. 1–7.

This plant was probably arborescent. The pinnæ were long and wide-spreading, with rigid rachises. The fragments obtained show at least tripinnate subdivision, but they are evidently parts of much larger portions. The pinnules show a good deal of variation, according to their position on the pinnæ of various orders. They pass from entire pinnules in the upper and terminal parts, through pinnules with undulate or crenate margins, to those with serrately dentate and lobed margins, and finally into ultimate pinnæ. The entire pinnules are more or less triangular in form, with broad bases, and are falcate, with acute tips that are directed toward ends of the ultimate pinnæ. They are separate nearly to the base and decurrent on the lower side to form a narrow wing. They are attached by the entire base. The epidermis is firm and durable, so that parts of the plants are often well preserved. The nerves consist of a parent nerve that is inserted near the base of the pinnule and goes off at a small angle. This is forked, with the posterior branch forking again, and all the branches curving toward the anterior margin of the pinnule, or it may be only once forked in the more united pinnules in terminal parts. The pinnules with undulate or crenate margins have lateral nerves, mostly forked at their tips or else simple. In the serrately dentate and lobed pinnules the lateral nerves, one for each incision, are once forked, the forking occurring more deeply as the incising is deeper. The simple lateral nerves and the parts below the forking in the forked ones are parallel to one another. All the nerves are remote and distinct. The pinnules, in becoming incised, change their form, being oblong, with little or no falcation.

They are now slightly contracted at the attachment of their bases, but are still decurrent to form a wing. When the incision of the margins is least, they are undulate or crenate. With deeper incision they are serrately dentate or lobed, the teeth and lobes being acute and having more or less of the character of the simple pinnules into which the lobes, with increasing depth of incision, finally pass. These incised pinnules are attached at an angle of about 45°. The fertile pinnules show a greater tendency to obtuseness, the teeth and lobes being often less sharply serrate.

The sori are placed much as they are in *Dicksonia oregonensis*. In the simple pinnæ there is only one sorus, which is placed within the margin, on the end of the unforked branch of the nerves, in the anterior basal part of the pinnule. The great size of the sorus causes it to fill much of the basal part of the pinnule on the upper side of the parent nerve. In the incised pinnules there is one sorus for each tooth or lobe, and they are placed on the ends of the lateral nerves. The sori are without indusium, and under the pressure to which they have been subjected appear as flat, rounded patches, with a granulation, which is apparently due to the naked capsules. The granules are grouped around a central point, which seems to have been the receptacle. When, however, the sori are seen with the upper surface of the pinnules presented uppermost, they are a good deal disguised and their true nature could not be made out. They are then smaller and appear as rounded prominences. The fructification seems near enough to that of Polypodium to justify the placing of the plant in that genus.

Owing to the considerable number of specimens that were obtained, a good idea can be formed of the plant. It must have been of large size, with widespread pinnæ, for in their great length they contrast strongly with those of *Dicksonia oregonensis*. As in the case of this last-named plant, by putting together fragments from different parts of the compound pinna a partial restoration may be made. It is a much more elegant fern than *D. oregonensis*.

Pl. VIII, Fig. 12, gives fragments of two penultimate pinnæ, which carry ultimate pinnæ and sterile simple pinnules. The penultimate pinnæ were evidently once united to a pinna of superior order. The fragments come from near the ends of the penultimate pinnæ or else from high up on

a compound pinna. Pl. VIII, Fig. 13, shows one of the pinnæ enlarged, and Fig. 14 gives a portion magnified two diameters to show the nerves. Pl. VIII, Fig. 15, shows a small fragment of a penultimate pinna, with ultimate pinnæ to which are attached fertile pinnules, which present their upper surface uppermost; hence the sori are disguised. As is often the case, these fertile pinnules differ somewhat from sterile ones that come from similar parts of the compound pinna. They are wider in proportion to length and more obtuse. Pl. IX, Fig. 1, represents a larger specimen, having sterile pinnules, from a position lower down on the compound pinna than that shown in Pl. VIII, Fig. 12. They are undulate or dentate. Pl. IX, Fig. 2, shows an enlarged pinna. Pl. IX, Fig. 3, represents a fragment from a still lower position, carrying portions of ultimate pinnæ and sterile, serrately toothed pinnules. Pl. IX, Figs. 4 and 5, show magnified pinnules of this. Pl. IX, Fig. 6, gives terminal portions of ultimate pinnæ that apparently correspond with the parts represented in Fig. 3, but these are narrowed by distortion from pressure, the margins being pressed into the rock. If we suppose the parts represented in Figs. 3 and 6 to be combined, we may get some idea of the expanse of this elegant fern. Pl. IX, Fig. 7, gives a small fragment comparable to the portion shown in Fig. 3, but from a lower position on the compound pinna, where the pinnules, by deeper incision, begin to pass into ultimate pinnæ. Pl. IX, Fig. 8, shows one of these pinnules enlarged. Pl. X, Fig. 1, depicts a specimen of considerable size, it being a portion of a penultimate pinna to which are attached a considerable number of ultimate pinnæ, carrying crenately toothed fertile pinnules. Unfortunately most of these pinnules are considerably distorted, being narrowed by having their margins pressed down into the rock. Pl. X, Fig. 2, represents the terminal parts of several ultimate pinnæ with fertile pinnules corresponding in position to the fragment represented in Fig. 1, but in this case they are not distorted. From these the true form of those given in Fig. 1 may be determined. Pl. X, Fig. 3, shows a single pinnule of this specimen enlarged to show the sori. Pl. X, Fig. 4, shows a fine specimen. It is a fragment of a penultimate pinna with ultimate pinnæ, carrying fertile pinnules of the largest size. They are more deeply incised than the pinnules shown in Fig. 1, and apparently come from lower down on the compound pinna, where the pinnules tend to pass into ultimate pinnæ. These fertile pinnules apparently correspond

in position on the compound pinna to the sterile ones shown in Pl. IX, Figs. 3 and 6. Pl. X, Fig. 5, gives a portion of one of these pinnules magnified two diameters to show the sori. Pl. X, Fig. 6, represents, with like enlargement, a sterile pinnule with crenate margins showing the lateral nerves. Pl. X, Fig. 7, gives, enlarged, two diameters, a fertile entire pinnule, to show the sorus.

This fossil is not so abundant as *Dicksonia oregonensis*, but it is one of the most common ferns, ferns being much less common than cycads. It occurs most commonly, and in the best specimens, at locality No. 19, but is also found, not rarely and in good specimens, at locality No. 18. It occurs also at localities Nos. 1, 2, 7, and 16.

Genus CLADOPHLEBIS Brongniart.

Cladophlebis vaccensis Ward n. sp.

Pl. X, Figs. 8–12.

1896. *Cladophlebis whitbiensis tenuis* var. a Heer. Font.: Am. Journ. Sci., 4th ser., Vol. II, p. 274 (nomen.).

1900. *Cladophlebis whitbiensis tenuis*, var. a Heer? Font.: Twentieth Ann. Rep. U. S. Geol. Surv., 1898–99, Pt. II, p. 346.[a]

A fern of the Cladophlebis type of the general form illustrated in *Cladophlebis whitbiensis*, but not identical with the species of Lindley and Hutton, is found sparingly at some of the Oregon localities. It is always in a very fragmental condition, most of the specimens showing only bits of ultimate pinnæ with attached pinnules. No fructification was seen. The constant absence of fructification on ferns of this type is a noteworthy feature. The largest specimens obtained give, at most, portions of ultimate pinnæ so placed as to show that they were once attached to a common rachis. The size of the rachises and their rigid aspect indicate that the plant must have attained considerable size and have been probably subarborescent. There is a considerable variation in the pinnules in shape and texture, which may perhaps be accounted for by different positions on the compound pinna, or different preservation. The forms graduate into one another in such a way that they can not well be separated. The pinnæ are long and slender, with a rigid rachis. The pinnules have a

[a] Professor Fontaine does not in his report mention the occurrence of this form in the Oroville beds, and he cites a different figure in Heer's work, but both figures refer to Heer's variety a. In correspondence he admits that the Oroville and Oregon forms are the same.—L. F. W.

rather thick coriaceous texture, and, notwithstanding the fragmentary condition of the specimens, are often very well preserved. They are widest at base, attached by the entire base, and often strongly falcate. In terminal parts they are sometimes shorter, less falcate, and more triangular in form. They are in these parts more or less united, but usually are separate to the base. They are acute to subacute. The nerves are very distinct and are of the typical Cladophlebis type. The basal lateral nerves are twice forked. Those higher up are less copiously branched, the highest being once forked. The branches diverge strongly at first and are then parallel, so that they appear rather straggling.

This plant agrees very well with the form described by Heer from the Jurassic of Siberia under the name *Asplenium whitbiense tenue*.[a] It is nearest his variety *a*, as figured on pl. xvi, fig. 8.

As these ferns are not specifically identical with the original *Pecopteris whitbiensis* it seems best not to treat them as a variety of that species, and, as they are without fructification, it is safest to refer them to the noncommittal genus Cladophlebis. They are very much like the *Neuropteris recentior* (Phill.) L. & H., figured by Lindley and Hutton,[b] but the pinnules are usually much more acute than those given for the English plant. It may be, however, that the bluntness of those of the latter is due to distortion or imperfect preservation, for a few of them are as acute as those of the Oregon fossil and have exactly the same shape.

Mr. Seward has been kind enough to send me, along with the names of the plants figured, duplicates of the plates for his forthcoming work on the Yorkshire Jurassic Plants. The plates were not accompanied by descriptions, hence reference can be made only to the plates and figures. The work will be referred to as "Yorkshire Jurassic Fossils."[c] In his paper entitled: "Notes on some Jurassic Plants in the Manchester Museum," which deals with some of these plants, he has, on pp. 8–11, brought together a large number of ferns of the *whitbiensis* type. In these

[a] Fl. Foss. Arct., Vol. IV, Pt. II, pp. 38–40, pl. xvi, fig. 8.

[b] Fos. Fl. Gt. Brit., Vol. I, pp. 195–196, pl. lxviii.

[c] The work was not received in America till after Professor Fontaine's report had been completed and the manuscript and types sent by him to Washington in the spring of 1901. Copies arrived, however, before the report had been embodied in this paper, and I have made free use of it in working out the synonymy and arranging the species in systematic order. A copy of it was placed in Professor Fontaine's hands, and there has been considerable correspondence between us relative to critical points. The final decision in all cases, as proposed or accepted by him, has been embodied in the terminology here introduced. In the present case he has decided to make a new species, and left the work of naming it to me.—L. F. W.

are included the *Pecopteris whitbiensis* Brongn. and the *Pecopteris tenuis* Schouw, described by Brongniart. These he considers as identical with *Pecopteris Williamsonis*, all being Todites. To these forms he gives the name *Todites Williamsoni*. In the paper on the plants of the Manchester Museum, pl. i, figs. 1, 2, he gives reproductions of two rather poorly preserved specimens of *Todites Williamsoni*, that, with the exception of the smaller size of the pinnules, and the serration of their margins, agree pretty well with the Oregon plant. Pl. xxi, fig. 6, of his Yorkshire Jurassic plants, gives as this plant a fern that seems to have pinnules with entire margins. This is exactly like the Oregon fossils. In the absence of fructification with the latter it can not be made a Todites notwithstanding this close similarity.

Pl. X, Fig. 8 shows parts of several ultimate pinnæ so placed as to indicate a former attachment to a common rachis. Fig. 9 gives a magnified pinnule to show the nervation. Fig. 10 gives a portion of an ultimate pinna, with pinnules more remote than is common. Fig. 11 shows a pinnule of this enlarged, with nervation in detail. Fig. 12 shows the tip of an ultimate pinna, with shorter, more triangular, and more united pinnules than is common in such situations.

This is one of the rarer ferns and where it occurs but few specimens were found. It occurs at the locality No. 19[a] most commonly, and is found also at localities Nos. 1, 2, 6, 7, 17, and 18.

CLADOPHLEBIS DENTICULATA (Brongniart) Nathorst non Fontaine.

Pl. XI, Figs. 1–7.

1828. *Pecopteris denticulata* Brongn. [non Heer]: Prodrome, pp. 57, 198 (nomen).
1828. *Pecopteris Phillipsii* Brongn.: loc. cit. (nomen).
1829. *Pecopteris ligata* Phill.: Geology of Yorkshire, pp. 148, 189, pl. viii, fig. 14.
1833. *Neuropteris ligata* (Phill.) L. & H.: Foss. Fl. Gt. Brit., Vol. I, p. 197, pl. lxix.
1834. *Pecopteris insignis* L. & H.: op. cit., Vol. II, p. 69, pl. cvi.
1834. *Pecopteris undans* L. & H.: op. cit., Vol. II, p. 103, pl. cxx.
1834. *Pecopteris denticulata* Brongn.: Hist. Vég. Foss., Vol. I, p. 301, pl. xcviii, figs. 1, 1A, 1B, 2, 2A.
1834. *Pecopteris Phillipsii* Brongn.: op. cit., Vol. I, p. 304, pl. cix, figs. 1, 1A.
1836. *Phlebopteris ? undans* (L. & H.) Brongn.: op. cit., Vol. I, p. 375, pl. cxxxiii, figs. 3, 3A, 3B

[a] The specific name alludes to this locality (bed of Cow Creek).—L. F. W.

1836. *Alethopteris Phillipsii* (Brongn.) Göpp.: Syst. Fil. Foss., p. 304.
1836. *Alethopteris insignis* (L. & H.) Göpp.: op. cit., p. 307.
1836. *Polypodites undans* (L. & H.) Göpp.: op. cit., p. 345.
1848. *Alethopteris denticulata* (Brongn.) Göpp.: Index Pal., Nomenclator, p. 23.
1849. *Cladophlebis ligata* (Phill.) Brongn.: Tableau, p. 105.
1865. *Pteris ligata* (Phill.) Ett.: Farnkräuter der Jetztwelt, p. 113.
1865. *Pteris insignis* (L. & H.) Ett.: op. cit., p. 114.
1874. *Cladophlebis insignis* (L. & H.) Schimp.: Pal. Vég., Vol. III, p. 505.
1876. *Cladophlebis denticulata* (Brongn.) Nath. [non Font.]: Bidrag till Sveriges Foss. Fl., Växter fr. Rät. Form. vid Pålsjö, p. 19.
1878. *Asplenium petruschinense* Heer: Fl. Foss. Arct., Vol. V, Pt. II (Beitr. z. Foss. Fl. Sibiriens), p. 3, pl. i, figs. 1, 1b.
1882. *Pteris frigida* Heer: Fl. Foss. Arct., Vol. VI, Abth. II, Foss. Fl. Grönl., Pt. I, pp. 3, 25, pl. ii, fig. 13; pl. vi, fig. 5b; pl. x, figs. 1–4; pl. xi, figs. 1–4, 5a, 6, 7a, 8a, 9–11; pl. xiii, figs. 2, 2b; pl. xvi, figs. 1, 2; pl. xviii, fig. 10b.
1882. *Pteris longipennis* Heer: op. cit., p. 28, pl. x, figs. 5–13; pl. xiii, fig. 1.
1888. *Cladophlebis denticulata* Font. [non (Brongn.) Nath.]:[a] Potomac Flora, p. 71, pl. iv, figs. 2, 2a; pl. vii, figs. 7, 7a.
1896. *Cladophlebis stewartiana* Hartz: Medd. om Grønl., Vol. XIX, p. 231, pl. xi, figs. 1, 2; pl. xii, figs. 2, 3.
1896. *Asplenites ??* sp. Hartz: op. cit., p. 231, pl. xi, figs. 3, 3a.

Fragments of what was evidently a large fern of Cladophlebis type were found sparingly at some of the localities. Considering the strength of some of the parts preserved, and their good state of preservation, the comminution of this fern is remarkable. Only sterile forms were found. The largest specimens show only small bits of ultimate pinnæ. Some yield only scattered pinnules and fragments of pinnules. The pinnules seem to have had a leathery, firm texture. The rachis of the ultimate pinnæ is strong and rigid. The pinnules are more or less falcate, sometimes strongly so. They are attached by the whole of a somewhat expanded base. The larger normal pinnules are oblong linear in form, with lancet-shaped subacute tips. Those in terminal parts are shorter, sometimes approaching a triangular form. The nervation is quite characteristic. The midnerve is strong and persists to near the tip of the pinnule, having

[a] Professor Fontaine described this as a new species, but he notes its resemblance to *Pecopteris denticulata* Heer non Brongniart from the Cretaceous of Greenland. Mr. Seward places it in his synonymy of the Yorkshire plant which was described under that name by Brongniart in 1834, and which Nathorst seems to have been the first (1876, see synonymy) to refer to Cladophlebis. Mr. Seward, however, does not include Heer's plant in his synonymy, and in mentioning it on p. 141 he seems to think that it was the same as Brongniart's, but Heer's was also called a new species. This makes an unfortunate confusion of names of closely related forms, which it is difficult to make clear.—L. F. W.

less than usual of the Cladophebis character. The lateral nerves are strong and very distinct. They are given off at an angle of about 45°, and fork near their insertion. The branches diverge strongly, then become parallel and turn outward to meet the margin under a large angle. One of the branches may fork again, but they are mostly single. Some of the pinnules appear denticulate near their tips, but this may be due to laceration and imperfect preservation. The larger pinnules are about 24 mm. long and 6 mm. wide.

This fine fern seems identical with the *Pecopteris insignis* of Lindley and Hutton.[a] The larger pinnules are exactly like the form given by Phillips for this species.[b] Seward, in his paper on the Jurassic Plants in the Manchester Museum, identifies this and a number of other species with *Cladophlebis denticulata* (Brongn.) Nath., and on pl. iv he gives a figure of *C. denticulata* that agrees well with the Oregon plant. The pinnules of this plant resemble so much those of the fine *Danæopsis Storrsii*, described farther on, that I am inclined to think that they are the sterile forms of that fossil.

Lindley and Hutton described from the Yorkshire Oolite a fertile fern under the name *Pecopteris undans*,[c] giving a fructification like that of *Danæopsis Storrsii*. Seward, in the paper above quoted, p. 19, states that Nathorst had suggested that *Pecopteris undans* may be the fertile pinna of *Cladophlebis denticulata*, and further that an examination of several examples of *Pecopteris undans* enabled him to confirm Nathorst's opinion. The fructification, as given by Lindley and Hutton in the figure of *P. undans*, is strikingly like that of *Danæopsis Storrsii* and would make the plant a Danæopsis. Seward gives no reason for connecting *Cladophlebis denticulata* with this plant. There is no connection between *Danæopsis Storrsii* and the Oregon form referred to *Cladophlebis denticulata*, hence the latter must remain in the genus Cladophlebis. It is, however, significant to find that in both these cases the idea is suggested that the fructification of this Cladophlebis is that of Danæopsis. It should be stated that Seward does not in his remarks indicate the resemblance of the fructification of *Pecopteris undans* to that of Danæopsis.

[a] Foss. Fl. Gt. Brit., Vol. II, p. 69, pl. cvi.
[b] Phillips, Geology of Yorkshire, 3d ed., p. 206, lign. 17.
[c] Foss. Fl. Gt. Brit., Vol. II, pp. 103–104, pl. cxx.

Pl. XI, Fig. 1, shows the most complete specimen, which is a fragment of an ultimate pinna having several pinnules. These are distorted and slickensided. The production of slickensides is not an uncommon feature in the Oregon plants whenever they have a firm resisting texture. The creep of the rock seems often to have taken place along the surface of the plant, polishing it and obliterating the nerves. Fig. 2 shows an enlarged pinnule of this. Fig. 3 depicts a fragment of an ultimate pinna, having one entire pinnule that shows indications of denticulation toward its tip. This pinnule is shown enlarged in Fig. 4. Fig. 5 gives a small fragment of an ultimate pinna with several pinnules of the more slender kind. Fig. 6 shows two fragments of ultimate pinnæ with mutilated pinnules that occur toward the termination of the pinnæ. Fig. 7 gives a pinnule enlarged to show the nerves.

The plant is most common, but still rare, at locality No. 19, and is found also at localities Nos. 1, 2, 7, 9, 12, 14, 17, and 18.

CLADOPHLEBIS HAIBURNENSIS (Lindley & Hutton) Brongniart ?

Pl. XI, Figs. 8–10.

1836. *Pecopteris haiburnensis* L. & H.: Foss. Fl. Gt. Brit., Vol. III, p. 97, pl. clxxxviii.
1849. *Cladophlebis haiburnensis* (L. & H.) Brongn.: Tableau, p. 105.
1865. *Pteris haiburnensis* (L. & H.) Ett.: Farnkräuter der Jetztwelt, p. 114.
1869. *Alethopteris haiburnensis* (L. & H.) Schimp.: Pal. Vég., Vol. I, p. 565.
1890. *Thinnfeldia haiburnensis* (L. & H.) Rac.: Bull. Int. Acad. Sci. de Cracovie, janvier, 1890, p. 32.

A single specimen of a fern of marked Cladophlebis type was found at locality No. 1. It seems different from any of the other Cladophlebis of the Oregon Jurassic. The specimen shows only a fragment of an ultimate pinna carrying several pinnules. These agree so well with the fern called by Lindley and Hutton *Pecopteris haiburnensis*[a] that it is most probably the same species. The English fern is clearly a Cladophlebis and not a Pecopteris. The amount of material, however, is not sufficient to justify a positive identification. It may possibly be an abnormal form of *Cladophlebis vaccensis*, but the entire aspect of the plant is different from that fern. The rachis is slender. The pinnules are slightly falcate and attached by the entire, somewhat widened base. They are in form

[a] Foss. Fl. Gt. Brit., Vol. III, pp. 97–98, pl. clxxxviii.

oblong and narrow toward their tips, so as to have obtuse lancet-shaped ends. They are quite wide in proportion to their lengths. The nerves are slender. The midnerve splits up, about two-thirds of the distance from base to tip, into numerous branches. The lateral nerves go off obliquely and are twice forked in the lower ones, the forking lessening in ascending.

Phillips gives a figure of *Pecopteris haiburnensis*[a] in which the pinnules are smaller than those in Lindley and Hutton's figure, but are still somewhat larger than those of the Oregon plant. The difference in size is probably due to a different position on the compound pinna. A more important difference between the English and Oregon plants is in the decurrence of the pinnules given in the figures of Phillips and of Lindley and Hutton. It is probable that both of these figures are of the same specimen. In the more complete figure of Lindley and Hutton there seems to be some distortion, which may account for the decurrence.

Pl. XI, Fig. 8, shows the specimen natural size, and Figs. 9 and 10 enlarged pinnules with detailed nervation.

CLADOPHLEBIS ACUTILOBA (Heer) Fontaine n. comb.

Pl. XI, Figs. 11, 12.

1876. *Dicksonia acutiloba* Heer: Fl. Foss. Arct., Vol. IV, Pt. II (Jura-Fl. Ostsibiriens), p. 92, pl. xviii, figs. 4, 4c.

A small Cladophlebis was found in five specimens, two each at localities Nos. 7 and 18, and one at No. 17. The specimens are small and show only fragments of penultimate pinnæ, which contain portions of ultimate pinnæ that carry a number of pinnules. The latter are very small. The rachis is narrowly winged. The pinnules nearer the rachises of the pinnæ are ovate-elliptical, widest below their middle, and constricted at base. Those higher up are more or less triangular and more united. All have acute tips. The larger pinnules are 3–4 mm. long. The nerves are distinct. The midnerve splits up into branches. The lateral nerves, few in number, are given off obliquely, and are mostly unforked. No fructification occurs. This plant resembles Saporta's *Cladophlebis breviloba* from the Middle Oolite of France,[b] but the rachis is much more

[a] Geology of Yorkshire, 3d ed., p. 211, lign. 25.
[b] Pal. Francaise, Plantes Jurassiques, Vol. I, pp. 303, 305, pl. xxxiv, fig. 1.

slender and the pinnules are more acute. It is more like the plant that Heer calls *Dicksonia acutiloba*,[a] and no doubt it is the same species. It is not clear why Heer regarded this plant as a Dicksonia. He does not say that he found fructification on it. In the absence of that, and in view of its obvious Cladophlebis features, it should be placed in this genus.

Pl. XI, Fig. 11, gives one of the specimens, and Fig. 12 an enlargement of one of the pinnules.

CLADOPHLEBIS PECOPTEROIDES Fontaine n. sp.

Pl. XI, Figs. 13–15.

An elegant fern, with finely-cut foliage, was found in two specimens at locality No. 1. One of the specimens is quite small and shows only a terminal portion of the penultimate pinna that comes apparently from high up on the compound pinna. The other one, given in Fig. 29, shows considerable portions of the penultimate pinnæ that seem to come from low down on the compound pinna. They are so placed as to show that they were once attached to the rachis of a pinna of superior order. By the small diminution of the pinnules they indicate that the ultimate pinnæ, of which they formed parts, had a very considerable length. The rachises of these pinnæ are strong, with their margins raised cord-like, and they have a cord-like rib running down their centers. These pinnæ carry a number of pinnules that for a considerable distance maintain a very uniform size. The pinnules are closely approximate, sometimes overlapping, and are falcate and 4–5 mm. wide. The pinnules are linear-oblong in form. They are about 1 cm. long, with obtuse or subacute tips. Their character gives the plant a marked elegance. They are set on the rachis at an angle of about 45°, and are more or less deeply incised into oblong or ovate, very obtuse lobes. The deepest incision goes about two-thirds of the way to the midnerve. These lobes or pinnules are strikingly like those of some of the Carboniferous pecopterids and the species is named from this resemblance. The nervation, however, is that of Cladophlebis. The leaf substance is quite thick and obscures the nerves. Apparently the lobes, in lower parts of the compound pinna, pass into distinct pinnules, which may have crenate margins. In terminal parts, on the other hand, the lobed pinnules diminish to those with

[a] Fl. Foss. Arct., Vol. IV, Pt. II, (Beitr. z. Jura-Flora Ostsibiriens), p. 93, pl. xviii, fig. 4.

crenate margins. In each lobe there is a parent nerve that splits up into branches. It may give off one or more pairs of lateral nerves that go off very obliquely. The nerve group has a flabellate character. No fructification was found. The plant is probably a new species. It resembles very much the *Pecopteris obtusifolia* (Murray) Lindley & Hutton[a] and may be the Oregon representative of it. In the English fossil, however, the ultimate pinnæ, corresponding to the pinnules of this plant, are much longer, and fructification was found. Phillips identifies the species of Lindley & Hutton with his *Pecopteris exilis*.[b] Seward regards *Pecopteris exilis* as a Klukia.[c]

Pl. XI, Fig. 13, shows the specimen natural size, and Figs. 14 and 15 give enlargements to show details of nerves.

Genus SCLEROPTERIS Saporta.

Scleropteris oregonensis Fontaine n. sp.

Pl. XII, Figs. 1–3.

A single specimen of a fern was found of pretty good size and fairly well preserved at locality No. 19. According to Saporta's diagnosis of the genus Scleropteris,[d] this genus clearly includes the plant in question. The specimen shows a considerable portion of a penultimate pinna, which bears fragments of a number of ultimate pinnæ, with pinnules. The ultimate pinnæ are very short, the longest of them not surpassing about 3 cm. The rachis is narrowly winged. The pinnules are rigid and have a very thick leaf substance that conceals the nerves, so that they generally are difficult to make out. The lowest pinnule on the upper side of the rachis is oblong, obtuse, and larger than the rest. It is crenate on the margins or has shallow obtuse teeth. The other, and normal pinnules, are not more than 5 mm. long and about 3 mm. wide. They are entire, oblong-elliptic in form, with very obtuse tips, and go off obliquely from the rachis, with a slight inclination toward the ends of the pinnæ. They are decurrent, forming the wing. All the pinnules are constricted at base. The nerves are immersed apparently in the leaf substance. They are composed of a parent nerve

[a] Foss. Fl. Gt. Brit., Vol. III, pp. 15–16, pl. clviii, fig. 1.
[b] Geology of Yorkshire, 3d. ed., p. 210, pl. viii, fig. 16.
[c] Jurassic Plants in the Manchester Museum, p. 4; Jur. Fl. Yorkshire Coast, p. 130.
[d] Pal. Française, Plantes Jurassiques, Vol. I, pp. 364–365.

that goes off obliquely and which has several lateral nerves that depart under a small angle and seem to be single. The plant seems to be a new species. It has some resemblance to *Scleropteris Pomelii*, but the pinnæ are shorter and the pinnules are shorter in proportion to their width. They are also more closely placed and more obtuse. It is more like Heer's *Dicksonia gracilis*,[a] but differs from that in the heteromorphous basal pinnule and in the shorter ultimate pinnæ. It is near enough, however, to be regarded as perhaps a representative of the Siberian fossil in the Oregon Jurassic. Pl. XII, Fig. 1, shows the only specimen found, Fig. 2 a pinna enlarged, and Fig. 3 an enlarged normal pinnule.

Genus RUFFORDIA Seward.

RUFFORDIA GŒPPERTI (Dunker) Seward.[b]

Pl. XII, Figs. 4–8.

1844. *Cheilanthites Gœpperti* Dunk.: Norddeutsch. Wälderthon, Programm der höheren Gewerbschule in Cassel, 1843–1844, p. 6.
1846. *Sphenopteris Gœpperti* Dunk.: Monogr. d. Norddeutsch. Wealdenbildung, p. 4, pl. i, fig. 6; pl. ix, figs. 1–3.
1846. *Sphenopteris Hartlebeni* Dunk.: op. cit., p. 4, pl. ix, fig. 9.
1846. *Sphenopteris longifolia* Dunk. [:non Phill. nec Feistm.]: op. cit., p. 4, pl. viii, fig. 6.
1851. *Sphenopteris adiantifrons* Ett.: Jahrb. d. k. k. Geol. Reichsanst., Jahrg. II, p. 157.
1852. *Sphenopteris Jugleri* Ett.: Beitr. z. Fl. d. Wealdenperiode, p. 15, pl. iv, fig. 5.
1870. *Sphenopteris Auerbachi* Trautsch.: Der Klin'sche Sandstein, Nouv. Mém. Moscou, Vol. XIII, p. 207 [19], pl. xviii, fig. 5.
1881. *Sphenopteris valdensis* Heer [in part]: Fl. Foss. du Portugal, p. 14, pl. xv, fig. 11.
1889. *Sphenopteris* sp. Yok.: Journ. Coll. Sci. Imp. Univ. Japan, Vol. III, Pt. I, p. 34, pl. xiv, figs. 13, 13a.
1894. *Ruffordia Gœpperti* (Dunk.) Sew.: Wealden Flora, Pt. I, pp. 76, 77, pl. iv; pl. v; pl. x, figs. 1, 2.

[a] Fl. Foss. Arct., Vol. IV, Pt. II, p. 92, pl. xvii, fig. 3.

[b] Mr. Seward (Wealden Flora, Pt. I, p. 76) includes in his synonymy of this species the *Sphenopteris Phillipsii* of Mantell, published in 1833, or eleven years earlier than Dunker's *Cheilanthites Gœpperti*, but still prefers Dunker's specific name on the ground that Mantell's specimen was a fragment "so small that its real nature must remain uncertain," but without saying whether he had seen it. As the use of Mantell's name in the synonymy would change the combination, our only course is to omit it, as *Fucoides arcuatus* L. & H. was omitted from the synonymy of *Marchantites erectus* (Bean) Seward.—L. F. W.

Phillips[a] gives a figure, with no description, of a singular plant that he calls *Sphenopteris Jugleri*.[b] This, in general aspect, agrees so well with one found in two specimens, one each at localities Nos. 2 and 7, that I think they belong to the same species. The Oregon plant has apparently no foliage, but is composed of a thread-like stem, which was probably succulent, as no vascular tissue shows in it. This rachis branches in an irregular straggling manner, widely diverging after each branching. It bears, irregularly placed, short branches, or contracted pinnules, that sometimes are forked and sometimes single. Their summits are expanded into elliptical forms, so that the branch is club-like in shape. No nerves are visible. Each expanded tip contains a rounded body, depressed in the center, that looks much like a sorus. The preservation is not sufficient to show its true nature, but, if it is a sorus, it probably had an indusium. This plant much resembles Schenk's *Acrocarpus cuneatus*,[c] from the Rhetic, but the segments are much smaller than those of that plant.

Pl. XII, Figs. 4 and 7 give different fronds; the latter is a small fragment, but more distinct. Fig. 5 gives an enlargement of a portion of Fig. 4, and Fig. 6 a pinnule still more enlarged. Fig. 8 shows a portion of Fig. 7 much enlarged.

Genus ADIANTITES Göppert.

ADIANTITES NYMPHARUM Heer?

Pl. XII, Figs. 9–11.

1876. *Adiantites Nympharum* Heer: Fl. Foss. Arct., Vol. IV, Pt. II (Jura-Fl. Ostsibiriens), p. 93, pl. xvii, figs. 5, 5b.

Very imperfect specimens were obtained, one each from localities Nos. 2, 7, and 19, of a plant that resembles Heer's *Adiantites Nympharum*. The pinnules are always too much mutilated to show their true form, and only small bits of ultimate pinnæ were obtained. All that

[a] Geology of Yorkshire, 3d ed., p. 218, lign. 40.

[b] Professor Fontaine, before receiving the text of Mr. Seward's Jurassic Flora of the Yorkshire Coast, was inclined to identify the Oregon plant with *Sphenopteris Jugleri* Ett. on the strength of its resemblance to Phillips's figure, but in view of the fact that Mr. Seward says (p. 133) that this figure "does not do justice to the original," and also because Mr. Seward refers all the plants called *Sphenopteris Jugleri* Ett. to *Ruffordia Gœpperti*, it was decided that our plant must belong to that species.—L. F. W.

[c] Foss. Flor. der Grenzschichten, pp. 134, 135, pl. xx, figs. 9–12.

can be said is that the plant may be Heer's fossil. The pinnules are narrowed wedge-shape to the base and seem to have dentate margins. The nerves are composed of a parent nerve, which sends off very obliquely lateral nerves. The teeth on the margin seem to be acute and very obliquely placed, being mostly on the anterior margin of the pinnules.

Fig. 9 represents one of the specimens, Fig. 10 a portion enlarged, and Fig. 11 shows what seems to have been the original form of the pinnules.

Genus TÆNIOPTERIS Brongniart.

Forms like Tæniopteris are more common in the Oregon Jurassic flora than the ferns with smaller pinnules. I shall use the distinction suggested by Nathorst as an essential one between Tæniopteris and the unsegmented Nilsonias that, in shape, so much resemble Tæniopteris. This distinction is that the lamina of Tæniopteris is attached to the side of the midrib and in Nilsonia to the upper surface. This feature causes a Tæniopteris to show a distinct midrib, whether the upper or the under surface be presented uppermost. In the case of Nilsonia, however, when the upper surface is seen uppermost there is no visible midrib or axis. The nerves belonging to the lamina on opposite sides of the axis meet in a raised cord in the center of the position that would be occupied by the midrib if it were shown. But if the lower surface of a Nilsonia be presented uppermost the axis or midrib is seen, and, therefore, while the absence of a distinct midrib may be taken as showing that the plant is a Nilsonia, yet, in cases where a midrib is shown, one can not be sure that the plant is not a Nilsonia with its under surface presented uppermost.

There are in the Oregon collection a number of leaves that in their shape are like Tæniopteris. They are, however, never seen with their laminæ divided or segmented. They show no midrib, but have their lateral nerves meeting in a raised cord that occupies the central line of the position that would be occupied by the midrib if it were present. These leaves have uniformly in their laminæ a thin texture. In some the lateral nerves are always single and show no thickening toward their bases near their insertion on the central cord. Others, with the same unchanged thickness in the lateral nerves, have them rarely forked, but in such way as to show that the essential character here, too, is an

unforked condition. Notwithstanding the entire nature of the laminæ of these leaves I shall class them as Nilsonia.

There are other tæniopteroid forms in this flora that always show strong prominent midribs. They have a very thick leaf-substance that is often slickensided from the creep of the rock along their surface. The lateral nerves are, as a rule, forked, and are much stronger, or thickened, near their insertions. These nerves go off approximately or quite at right angles, and are not curved, while in the Nilsonias they go off obliquely and curve in a characteristic way to meet the margin. There is one exception to this character found in the form *Tæniopteris orovillensis*, to be noted further on. This has the midrib of Tæniopteris and the ateral nervation like that of the Nilsonias. The question might arise, Is not this really a Nilsonia with its under surface presented uppermost?

The leaves that I group as Tæniopteris very often occur with a number together in the same hand specimen of rock, as if they grew in clusters. Those regarded as Nilsonia are usually found in isolated fragments.

TÆNIOPTERIS OROVILLENSIS Fontaine.

Pl. XII, Figs. 12–17.

1896. *Tæniopteris orovillensis* Font.: Am. Journ. Sci., 4th ser., Vol. II, p. 274 (nomen).

1900. *Tæniopteris orovillensis* Font.: Twentieth Ann. Rep. U. S. Geol. Surv., Pt. II, 1898–99, p. 348, pl. lii, figs. 2–4.

This Tæniopteris, so abundant in the Oroville Jurassic flora, is found also at some of the Oregon localities. It is not so abundant and widely diffused as some of the other species of Tæniopteris. The nerves are fine but very distinct. They have the character, as mentioned above for Nilsonia, of being always single, not varying in strength from their insertions to their ends, and of going off at less than a right angle, and of curving in their course to meet the margin. The leaves, however, have a much thicker and more coriaceous texture than those regarded as Nilsonias, and the midrib is strong. The size of these leaves varies a good deal. The most common forms have the sizes seen in the Oroville specimens, but occasionally fragments are found indicating a somewhat wider leaf than any seen in the Oroville plants.

In the description of this species given in the Twentieth Annual Report of the United States Geological Survey, Pt. II (p. 348), the statement, by misprint, is made that "the fronds vary in length from 1–4 cm." For "length" read width. The fragments seen indicate that some of the Oregon leaves may have reached the width of 5 cm.

Pl. XII, Fig. 12, shows the upper part of one of the larger leaves, and Fig. 13 a portion of this enlarged. Fig. 14 represents the basal portion of one of the narrower leaves that was evidently quite long. It is distorted by pressure. Fig. 15 gives the middle portion of one of the leaves of medium size. This, too, is distorted. Fig. 16 shows a leaf nearly entire, and Fig. 17 a portion of this enlarged.

The plant is most common at locality No. 2, where it is quite abundant. It is also found at localities Nos. 1, 7, 14, and 19.

TÆNIOPTERIS MAJOR Lindley and Hutton.

Pl. XIII, Figs. 1–3.

1833. *Tæniopteris major* L. & H.: Foss. Fl. Gt. Brit., Vol. II, p. 31, pl. xcii.
1836. *Aspidites Williamsonis* Göpp.: Syst. Fil. Foss., p. 353.
1843. *Pterozamites major* (L. & H.) Fr. Br. in Münster: Beitr. z. Petrefacten-Kunde, Vol. II, Heft VI, p. 29.
1865. *Tæniopteris Williamsonis* (Göpp.) Zign.: Osserv. sulle Felci Foss. dell' Oolite, p. 39.
1869. *Macrotæniopteris major* (L. & H.) Schimp.: Pal. Vég., Vol. I, p. 610.

Lindley and Hutton have described with the name *Tæniopteris major*[a] a fern that agrees so well with one found in the Oregon Jurassic that there can be no doubt that it is the same. The dimensions of the leaf and the size of the midrib in the two are the same, but there is some difference in the lateral nerves. In the figure given by Lindley and Hutton of the English plant these nerves are represented as very slender, and not varying in thickness from their insertions to their ends. They are also given as forking very copiously, especially at the margin of the leaves. In the Oregon fossil the lateral nerves are decidedly stronger near their bases, where they are attached to the midrib, than they are near the margin of the leaf. Owing to the great thickness of the leaf substance, and the fact that the plant is generally slickensided, it is difficult to see them distinctly. This is especially true of the parts near the margin of the leaves, for they have suffered

[a] Foss. Fl. Gt. Brit., Vol. II, pp. 31–32, pl. xcii.

more here than elsewhere. They, however, do not seem to show such copious forking here as the fossil of Lindley and Hutton. The following seems to be their character: The lateral nerves go off at a right angle, fork in a dichotomous manner, mostly at two-thirds of the distance from the midrib to the margin. Near the margin one or both of the branches may fork again. The forking occasionally occurs nearer the insertion of the nerves. The branches, after abruptly diverging, become more or less parallel. The lateral nerves of both the English and the Oregon plants form a very characteristic feature, and in the Oregon fossil readily distinguish the plant if they are visible. There is in the size and shape of the leaves no obvious general distinction between this plant and *Tæniopteris vittata* Brongn. In leaves of this type it could not be expected. The smallest forms of this plant resemble in size the largest of *T. vittata*, but these are exceptions. As a rule the plant now in question is much wider and less ribbon-shaped than *T. vittata*. The lateral nerves differ decidedly. The same hand specimen of rock often shows several imprints of this fossil, and, in one case, three leaves lie side by side as if they had formed a tuft of leaves in growing. This aggregation of imprints is to be seen in the case of *T. vittata* also. Some hand specimens show several imprints of both fossils.

Pl. XIII, Fig. 1, gives a fragment from the middle part of the frond mutilated, so as not to show its full width, the margin being missing. Indeed, it is rarely preserved in any of the specimens. Fig. 2 shows a portion of this enlarged. Fig. 3 shows the basal portion of another frond. This also is mutilated.

This plant occurs most commonly at locality No. 7, where it is rather abundant. It occurs also at localities Nos. 1, 2, 16, 17, and 19.

TÆNIOPTERIS VITTATA Brongniart.[a]

Pl. XIII, Figs. 4–8.

1822. *Scolopendrium* sp. Young & Bird: Geol. Survey of the Yorkshire Coast, p. 182, pl. ii, fig. 7.

1828. *Tæniopteris vittata* Brongn.: Prodrome, pp. 62, 199.

[a] Mr. Seward (Jur. Fl. Yorksh. Coast, p. 157) places the following at the head of his synonymy of this species:

"1823. *Scitaminearum folium*, Sternberg, Flora der Vorwelt, iii, p. 42, pl. xxxvii, fig. 2."

I find no such designation in Sternberg's work, and the language used by Mr. Seward seems to be borrowed from Brongniart. In his Prodrome, p. 62, he says: "*Tæniopteris vittata: Scitaminearum folium* ? Sternb., fasc. 3, pag. 42, tab. 37, fig. 2; Filicites ? ejusd. fasc. 4 (*in indice iconum*)." Practically the same entry is

1829. *Scolopendrium solitarium* Phill.: Geology of Yorkshire, p. 147, pl. viii, fig. 5.
1831. *Tæniopteris vittata* Brongn.: Hist. Vég. Foss., Vol. I, p. 263, pl. lxxxii, figs. 1, 1*A*, 2–4.
1836. *Aspidites Tæniopteris* Göpp.: Syst. Fil. Foss., p. 350.
1843. *Pterozamites vittatus* (Brongn.) Fr. Br. in Münster: Beitr. z. Petrefacten-Kunde, Vol. II, Heft VI, p. 29.
1869. *Oleandridium vittatum* (Brongn.) Schimp.: Pal. Vég., Vol. 1, p. 607.

Numerous specimens of a narrow Tæniopteris were obtained at some of the Oregon Jurassic localities. They agree very closely with *T. vittata*, and there is no doubt that they belong to this species. The specimens in shape and size resemble a good deal the narrower forms of *T. orovillensis*, and when the lateral nerves are not visible can not well be distinguished from that fossil. Unfortunately, in this case also, as in that of *T. major*, the leaf substance is so dense and the specimens are so much polished by slickensides that it is generally difficult to see them distinctly.

This fossil is generally narrowly elliptical to linear ribbon-shaped, narrowing gradually to the base and apex. The midrib is proportionally very strong, and is prolonged into a long stipe, indicating that the frond was simple. The lateral nerves are slender and rather remotely placed. They go off at nearly or quite a right angle, and go parallel to one another to the margin. They appear to be mostly simple, but are sometimes forked. The forking, however, takes place in no regular way and in no particular position, but seems, as it were, accidental. There is a considerable variation in the width and length of the leaves.

With some doubt I unite with this species the form depicted in Pl. XIII, Fig. 6, found in only a single specimen. This differs from the

made in the synonymy of this species in his Hist. Vég. Foss., Vol. I, p. 263. The reference is probably to the French edition, as there are only 40 pages in fascicle 3 of the original German edition, 1823. On page 37 of that fascicle Sternberg mentions the plant figured in pl. xxxvii, fig. 2, and says: "Fig. 2 scheint eher ein Blattstück einer Scitaminea als ein Farrenkraut zu seyn." He also states here that this specimen came from Stonesfield. On page 39 of the same fascicle he enters the plant systematically under the general head "Filicites" as "*Phyllites scitaminæformis*," referring to the same plate and figure. This name also occurs in the index iconum. It does not occur elsewhere in the work, but is the only binomial appellation that he applied to the plant. If it were certain that this specimen from Stonesfield belonged to the same species as the Yorkshire forms that Brongniart called *Tæniopteris vittata*, the proper name for the species would be that of Sternberg, which antedates Brongniart's name by five years. An examination of Sternberg's colored figure, however, makes this doubtful. The character of the nervation is obscured by the effort to be artistic, and not enough of the leaf is shown to be certain as to its shape. Certainly nothing short of a comparison of the type specimen could positively decide the question. This does not seem to have been done, and I therefore omit all reference to it from the synonymy of *Tæniopteris vittata*.—L. F. W.

ordinary form of *Tæniopteris vittata* in its unchanging width, throughout the specimen, indicating a very long and narrow leaf which must have been ribbon-shaped. It shows no lateral nerves.

Pl. XIII, Fig. 4, gives the lateral part of a leaf of the larger size, which shows a considerable part of the stipe. Fig. 5 shows the basal portion of a leaf of medium size. Fig. 6 represents the abnormally long and narrow leaf above referred to. Fig. 7 is a view of a fragment that shows the nerves, and Fig. 8 is a portion of this enlarged.

This plant is most common at locality No. 7, where it is abundant and occurs with *Tæniopteris major*, several of each sometimes being found in the same hand specimen of rock. It is found also at localities Nos. 1, 2, 4, 16, 17, and 19.

TÆNIOPTERIS ? OREGONENSIS Fontaine n. sp.

Pl. XIII, Figs. 9, 10.

At locality No. 8 was found a single imprint, with its reverse, of a plant of tæniopterid character. It is 5 cm. long and 1 cm. wide, with no marked change in width, indicating a leaf of considerable length in proportion to its width. The midnerve is proportionally strong and no lateral nerves are shown distinctly, as the leaf substance is rather thick. Traces of them, however, can be made out. They seem to go off at right angles to the midrib. It could not be determined whether they branch or not. Possibly this may be the same species with the narrow form placed in *Tæniopteris vittata*, but the leaf is much smaller. This fossil is much like the plant given by Heer as *Cycadites sibiricus*,[a] which is evidently not a Cycadites, but rather some form of Tæniopteris. As the amount of material does not suffice to fix the character of the plant, its position must be left doubtful. Pl. XIII, Fig. 9, represents the only specimen seen, and Fig. 10 a part of this enlarged.

Genus MACROTÆNIOPTERIS Schimper.

MACROTÆNIOPTERIS CALIFORNICA Fontaine.

Pl. XIV, Figs. 1–4.

1896. *Macrotæniopteris californica* Font.: Am. Journ. Sci., 4th ser., Vol. II, p. 274 (nomen).

1900. *Macrotæniopteris californica* Font.: Twentieth Ann. Rep. U. S. Geol. Surv., 1898–99, Pt. II, p. 349, pl. liii, fig. 1; pl. liv., figs. 1, 2.

[a] Fl. Foss. Arct., Vol. V, Pt. II, pp. 16–17, pl. iv, fig. 1.

Three specimens of a fine tæniopteroid plant were found at locality No. 7. It agrees so well with *Macrotæniopteris californica* of the Oroville flora that I have no hesitation in regarding it as the same. The Oregon specimens are better preserved than those found at Oroville and show the margins. The plant must have had a very thick leather-like texture, as it leaves on the rock a decided film of coal. The maximum width shown is 6 cm. The greatest length seen is 14 cm. and this in a mere fragment. The midnerve is strong. The lateral nerves are seen with difficulty. They are mostly unforked and parallel to one another. They are rather remote, being about three-fourths of a millimeter apart. Some are forked at rather more than half way between the midrib and margin. The forking, however, appears, as it were, accidental and not essential. The plant resembles Saporta's *Tæniopteris superba*,[a] but the nerves are more remote and not forked at the base, as in Saporta's fossil.

Pl. XIV, Fig. 1, gives the basal portion of a leaf. Fig. 2 represents a considerable part of a leaf from some distance above the base, indicating a leaf of great length. Fig. 3 gives a fragment in which the nerves are visible, and Fig. 4, a portion of this enlarged.

Family MARSILEACEÆ.

Genus SAGENOPTERIS Presl.[b]

Sagenopteris Gœppertiana Zigno.

Pl. XIV, Figs. 5–11.

1865. *Sagenopteris Gœppertiana* Zign.: Osserv. sulle Felci Fossili dell'Oolite, p. 36.
1865. *Sagenopteris Brongniartiana* Zign.: Loc. cit.
1865. *Sagenopteris Brauniana* Zign.: Loc. cit.
1865. *Sagenopteris rotundata* Zign.: Loc. cit., p. 35.
1868. ? *Sagenopteris Gœppertiana* Zign.: Fl. Foss. Form. Oolith., Vol. I, p. 188, pl. xxi, figs. 1a, 1b, 2–5; pl. xxii, figs. 1, 2.
1900. *Sagenopteris Nilsoniana* (Brongn.) Ward: Twentieth Ann. Rep. U. S. Geol. Surv., 1898–99, Pt. II, p. 352, pl. lvi, fig. 1; pl. lxvii, fig. 2.

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[a] Plantes Jurassiques, Vol. I, pp. 439–441, pl. lxi; pl. lxii, fig. 1.

[b] Potonié, who is working up the Pteridophyta for Engler and Prantl's Natürliche Pflanzenfamilien, classes this genus in the Marsileaceæ, following the views of Heer, Zigno, Feistmantel, Nathorst, and others; but Count Solms-Laubach sees reason to doubt the correctness of this, and Seward treats Sagenopteris as a fern, classing it now (Jur. Fl. Yorkshire Coast, 1900, p. 161) in the family Polypodiaceæ, although in his Wealden Flora, 1894, p. 129, he placed it in the Schizeaceæ.—L. F. W.

Zigno has described from the Lower Oolite of Italy a fossil with the name *Sagenopteris Gœppertiana*[a] that exactly resembles a plant occurring rather abundantly at some of the Oregon Jurassic localities. He gives a number of figures which show that the plant varies a good deal. Most of these variations can be seen in the Oregon specimens. The plant has a well-marked character. The largest Oregon leaves have a length of 9 cm. and a width in the widest portion of 35 mm. The leaves vary much in size and in other points. They are all decidedly inequilateral and tend mostly to assume a spatulate shape, widening toward their ends. Occasionally a leaf shows a narrowing at the tip, so that it is subacute. These seem to be the central leaves of a group. But most of them are very obtuse at their ends and rounded. These are rounded off toward their bases elliptically. They are apparently the lateral leaves of a group. Some of the obtuse leaves are narrowed gradually to their base, giving the base a prolonged wedge form. None were seen attached. The midnerve shows considerable variation. In the leaves with prolonged wedge-shaped bases it is carried two-thirds of the length of the leaf. In those with the most marked inequilateral forms and elliptic bases it is not so prolonged, going, at most, one-third of the length of the leaf; in some it is hardly at all developed. The secondary nerves are not distinct. They are very closely placed and slender, anastomosing so as to form long meshes. The branches in anastomosing meet at very acute angles. One form that seems to belong to this species is abnormal in being short, broad, and broadly elliptical, with a rounded base and hardly any development of midrib. Another is abnormal in being very small. It is only 5 cm. long. This is but slightly inequilateral and may be a form of *Sagenopteris paucifolia*. This is proportionally not smaller than the fossil given by Zigno, pl. xxi, fig. 2, but it is narrower and proportionally longer than Zigno's plant.

From an inspection of the more abundant and better material obtained at the Oregon localities, I am convinced that this plant is the one found in the Oroville flora and regarded as *Sagenopteris Nilsoniana*[b] (*S. rhoifolia* Presl.).

Pl. XIV, Fig. 5, represents a normal leaf that is strongly inequilateral, with a base that is rounded off in an elliptical form. Fig. 6 gives the ter-

[a] Flor. Foss. Form. Oolith., Vol. I, pp. 188–190, pl. xxi, figs. 1–5; pl. xxii, figs. 1, 2.
[b] Twentieth Ann. Rep. U. S. Geol. Surv., Pt. II, 1900, p. 352, pl. lvi, fig. 1; pl. lvii, fig. 2.

minal portion of what was probably a central leaf. This is less inequilateral than usual and is subacute at the tip. Fig. 7 shows a smaller sized inequilateral leaf, with a prolonged wedge-shaped base. Fig. 8 shows the basal portion of a large inequilateral leaf, with the wedge-shaped base less prolonged, and showing a trace of the stipe. Fig. 9 gives an abnormally small leaf. Fig. 10 shows an abnormal broad elliptic leaf, with little development of the midnerve. Fig. 11 shows the nerves better than most specimens.

The plant occurs abundantly at locality No. 19 and is not rare at No. 2. It also occurs at localities Nos. 1, 7, and 16.

Sagenopteris paucifolia (Phill.) Ward n. comb.[a]

Pl. XV, Figs. 1–3.

1829. *Pecopteris paucifolia* Phill.: Geology of Yorkshire, p. 148, pl. viii, fig. 8.
1829. *Pecopteris longifolia* Phill. (non Brongn.): Op. cit., p. 189, pl. viii, fig. 8 (probably misprint for *P. paucifolia*).
1830. *Glossopteris Phillipsii* Brongn.: Hist. Vég. Foss., Vol. I, p. 225, pl. lxi bis, fig. 5; pl. lxiii, fig. 2.
1835. *Otopteris cuneata* L. & H.: Foss. Fl. Gt. Brit., Vol. II, p. 203, pl. clv.
1836. *Acrostichites Phillipsii* (Brongn.[b]) Göpp.: Syst. Fil. Foss., p. 286.

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[a] This is the plant that Mr. Seward (Jur. Fl. Yorksh. Coast, p. 162) calls "*Sagenopteris Phillipsi* (Brongniart)." He heads the synonymy with the reference to Brongniart's Hist. Vég. Foss., p. 225, where he describes *Glossopteris Phillipsii*, but dates it 1828. This, it is true, is the date of the first volume, but it is well known that the work was published in parts, and it is very difficult now to ascertain the dates of the fascicles on account of the vicious habit of destroying the covers in binding such volumes. M. René Zeiller has been to great pains to determine the dates of the parts of this work and has been sufficiently successful for all practical purposes. His results may be found in the text to his monumental work on the flora of the coal basin of Valenciennes. (Ministère des Travaux Publics. Études des Gites Minéraux de la France. Bassin Houiller de Valenciennes. Description de la Flore Fossile, par R. Zeiller. Texte. Paris, 1888. Index bibliographique, pp. 701ff, cf. p. 703). From this it appears that page 225 was in the 5th livraison, issued in 1830 together with pl. lxi bis, containing the first figure. Pl. lxiii, containing the other figure, was included in the 6th livraison, which appeared in 1831 or 1832. Now as Brongniart puts *Pecopteris paucifolia* Phill. in his synonymy, it might have been seen that Phillips's work had then appeared, and that the date must have been later than 1829. This also shows that Brongniart regarded Phillips's plant as the same as his, coming as they all did from the same locality. He, of course, had no right to change the specific name, but the rules of nomenclature were very loose in those days and still are with some authors. There seems to be no escape from recognizing Phillips's name.—L. F. W.

[b] Although Göppert expressly excludes Brongniart's forms from his synonymy, and deals only with those of Lindley and Hutton, he retains Brongniart's specific name, which is incomplete without his authority attached. Göppert's reasons for separating the forms are no longer considered valid. Mr. Seward includes the *Aspidites Nilsonianus*, to which Göppert refers Brongniart's forms, in his synonymy, but they form only a part of it, and that name relates to Brongniart's *Filicites Nilsonianus*, which Presl later renamed *Sagenopteris rhoifolia* (cf. Twentieth Ann. Rep. U. S. Geol. Surv., Pt. II, 1900, p. 352). I therefore omit it from the synonymy of this species.—L. F. W.

1836. *Adiantites irregularis* Göpp.: Op. cit., p. 385.
1838. *Cyclopteris cuneata* (L. & H.) Presl [non (Göpp.) Ung. nec Carr.][a] in Sternberg: Flora der Vorwelt, Vol. II, p. 135.
1838. *Tæniopteris Phillipsii* (Brongn.) Presl in Sternberg: Op. cit., p. 140.
1843. *Sagenopteris ? cuneata* (L. & H.) Morr.: Cat. Brit. Foss., p. 20.
1849. *Phyllopteris Phillipsii* Brongn.: Tableau, pp. 22, 105.
1865. *Gymnogramme cuneata* (L. & H.) Ett.: Farnkräuter der Jetztwelt, p. 70.
1865. *Gymnogramme Phillipsii* (Brongn.) Ett.: Op. cit., p. 71.

Forms that agree exactly with *Sagenopteris paucifolia* are not rare at some of the Oregon Jurassic localities. The leaves vary a good deal in size but are pretty constant in general shape. They are narrowly elliptical, sometimes so narrow in proportion to their length as to be linear-elliptical. They narrow gradually to their bases and tips, so as to be lancet-shaped at the end and wedge-shaped at the base. The narrowing in some bases is more gradual than in others, so as to give the base a prolonged wedge shape. The nerves are not so closely or so copiously anastomosed as in *S. Gœppertiana* and are not so fine. The leaves are decidedly less inequilateral than in that species. Phillips[b] has pointed out that the nerves depicted in the figure of Lindley and Hutton[c] are not correctly given. Certainly no such nerves occur in the Oregon plants. The midnerve is more distinctly defined than in *S. Gœppertiana,* and is prolonged farther in the leaf. Seward[d] described two forms of this plant. One, the form called originally *Otopteris cuneata,* is not found in the Oregon collections. The other, given in fig. 8, agrees well with some of the Oregon plants.

Pl. XV, Fig. 1, represents one of the largest leaves. It is nearly entire. Fig. 2 gives a leaf with a base more elliptic in form. Fig. 3 shows the basal portion of one of the smallest leaves seen. This plant is nowhere abundant, but is pretty widely diffused. It is most common at locality No. 2, but occurs also at localities Nos. 1, 7, 14, 18, and 19.

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[a] Unger (Synops. Pl. Foss., p. 56) referred Göppert's Carboniferous species *Adiantites cuneatus* (Syst, Fil. Foss., p. 226) to Cyclopteris, and Carruthers (Quart. Journ. Geol. Soc. London, Vol. XXVIII, August. 1872, p. 354) named a new species *Cyclopteris cuneata* from the Carboniferous of Queensland.—L. F. W.

[b] Geology of Yorkshire, 3d ed., p. 203.

[c] Foss. Fl. Gt. Brit., Vol. I, pl. lxiii.

[d] Notes on some Jurassic Plants in the Manchester Museum, Manchester Memoirs, Vol. XLIV, Pt. III 1900, pp. 11–14, pl. iii, figs. 7, 8.

SAGENOPTERIS GRANDIFOLIA Fontaine n. sp.

Pl. XV, Figs. 4, 5.

A single imprint and its reverse of what must have been a very large leaf was obtained from locality No. 7. It is evidently a Sagenopteris quite different from either of the two above described. Unfortunately the fragment is too small to show the size and shape of the leaf. It is a portion of the upper part of a leaf and shows the margin on one side, a portion of the midnerve, and some of the secondary nerves. The width of the part preserved is 35 mm., indicating a leaf at least 7 cm. wide. The midnerve extends well up in the leaf. The secondary nerves are very strong, unusually remote, and flexuous. The anastomosis is more open and less frequent than in either *S. Göppertiana* or *S. paucifolia.*

Pl. XV, Fig. 4, gives the only fragment seen, and Fig. 5 an area drawn to show the nervation.

Family MARATTIACEÆ.

Genus DANÆOPSIS Heer.

DANÆOPSIS STORRSII Fontaine n. sp.

Pl. XV, Figs. 6–9.

Three specimens of a very fine fertile fern were found by Mr. Storrs at locality No. 14. It has been found nowhere else. The fructification is so near that of the living Danæa that it might be placed in that genus. As, however, Heer's fossil genus Danæopsis has a similar fructification, I prefer to place it in that genus. All three specimens seem to have belonged together, being separated in splitting the rock. The part figured has been mutilated, so as to separate what was once a continuous fragment of an ultimate pinna extending from well down on it to near its termination. The size of this indicates that the entire pinna must have had a very considerable length, for the part preserved has a length of 105 mm. This pinna evidently formed one of a number that were once attached to a common rachis. The larger or normal pinnules are about 25 mm. long and 7 mm. wide. On the specimen figured they are distorted and crowded together by pressure, causing them to appear unduly narrow. In form they are oblong-linear and they are more or less falcate. The tips are obtuse to subacute. They maintain the same width from the

base to some distance above it and are attached by the entire base. The midnerve of the pinnules is distinct and maintained to near their ends. The lateral nerves are not shown, but apparently in their place occur two closely approximate parallel, paired bands, that, to the unaided eye, look like very thick nerves. The lens shows that these bands are concrete rows of minute punctiform bodies that seem to be the capsules. These paired bands or rows leave the midnerve at a large angle, and, in the case of two adjacent bands, go from a common point. They go nearly parallel to one another, so as to meet the margin nearly at a right angle. The paired bands seem to follow lateral nerves, one member of the pair being on each side of a nerve.

This form is much smaller than the two Triassic fossils, *Danæopsis marantacea* Heer, and *D. Rumpfii* Schimp. As stated before, the general aspect of this plant is strikingly like that of *Cladophlebis denticulata*.

Pl. XV, Fig. 6, shows the most complete specimen. Fig. 7 shows an enlarged pinnule, and Fig. 8 a portion of this still further enlarged. Fig. 9 gives another enlarged pinnule to indicate the distribution of the capsules.

I name this plant for Mr. Storrs as a slight recognition of his valuable work in collecting these plants.

Order EQUISETALES.

Family EQUISETACEÆ.

Genus EQUISETUM Linnæus.

EQUISETUM ? sp. Fontaine.

Pl. XV, Fig. 10.

The collections show no remains of algæ and no unequivocal Equisetum. There are a few fragments of small stems that may be some form of Equisetum, but they are decorticated and of doubtful position. These fragments are about 5 mm. in width and sometimes 5–7 cm. long. They show ribs or cord-like cylindrical raised lines, running longitudinally, that do not seem to be any form of nerve. No articulations are indicated and no sheaths or teeth were seen. At most these forms are merely suggestive of Equisetum. They are among the rarest of fossils. Such a form occurs at localities Nos. 2, 7, and 19.

Phylum SPERMATOPHYTA.[a]

Class GYMNOSPERMÆ.

Order CYCADALES.

Family CYCADACEÆ.

Genus PTILOZAMITES Nathorst.

Ptilozamites Leckenbyi (Bean) Nathorst.

Pl. XVI, Figs. 1, 2.

1863. *Ctenis Leckenbyi* Bean in Leckenby: Quart. Jour. Geol. Soc. London, Vol. XX, p. 78, pl. x, figs. 1a, 1b.
1864? *Odontopteris ? Leckenbyi* (Bean) Zign.: Fl. Foss. Form. Oolith., Vol. I, p. 111.
1869. *Cycadopteris Leckenbyi* (Bean) Schimp.: Pal. Vég., Vol. I, p. 487.
1880. *Ptilozamites Leckenbyi* (Bean) Nath.: Öfv. K. Svensk. Vet.-Akad. Förh., Vol. XXXVII, No. 5, pp. 65, 83.

Phillips has given a figure of a plant which he calls *Odontopteris Leckenbyi* (Bean) Zign.,[b] that agrees exactly with a small fragment found at locality No. 19. Although the Oregon specimen is but a small fragment of an ultimate pinna, it has several perfect pinnules that show the nerves very distinctly. The form of the pinnules and the character of the nerves are so entirely characteristic that a single pinnule would suffice to identify the plant. The agreement of the pinnules and nervation with those points in Phillips's figure is exact. The rachis is slender. The pinnules are remote, attached by the entire base to the sides of the rachis and slightly decurrent. They are oblong, falcate, narrowed at the ends by having their posterior margins curve forward toward the ends of the pinna. The nervation is of the Odontopteris type. There is no midnerve, but the nerves go off at an oblique angle and curve suddenly and strongly away from the rachis. They are subparallel and branch several times, the center ones more copiously than the outer ones. The last branching is near the tip of the pinnule.

This species differs from *Ctenopteris cycadea* Sap., of the Lias, in the more falcate form of the pinnules, and especially in the more copious branching of the nerves. The fact that nearly all the branches again

[a] See footnote to Bryophyta, p. 53.

[b] Geology of Yorkshire, 3d ed., p. 218, lign. 41.

branch near the ends of the pinnule is a noteworthy feature. The general aspect of the plant is that of a cycad, and it is by no means certain that it is not one.[a]

Pl. XVI, Fig. 1, gives the only specimen seen, and Fig. 2 an enlargement of the same to show the details of nervation.

Genus NILSONIA Brongniart.

As stated under the head of Tæniopteris, there are in the Oregon Jurassic certain tæniopteroid forms, which, although constantly without segmentation, must be placed with Nilsonia, because the lamina is inserted on the upper face of the midrib. In place of the midrib, when the upper surface is presented uppermost, they show a cord in which the bases of the lateral nerves on each side of the midrib are inserted. When, however, the upper face is downward a midrib is visible. The plants have a rather well-defined character. The leaves were mostly thin and easily lacerated or puckered, giving sometimes a deceptive appearance of original segmentation. The lateral nerves are single, parallel, of equal strength from base to end, go off nearly at a right angle, and curve slightly toward the ends of the leaves. They thus contrast strongly with the true Tæniopterids. These unsegmented Nilsonias are the most abundant ones in the Oregon Jurassic, far surpassing the segmented forms.

NILSONIA ORIENTALIS Heer.

Pl. XVI, Figs. 3–9.

1878. *Nilsonia orientalis* Heer: Fl. Foss. Arct., Vol. V, Pt. II (Beitr. Foss. Fl. Sibiriens), p. 18, pl. iv, figs. 5–9.

Heer has described as *Nilsonia orientalis* a fossil that is evidently the same as a plant that is quite widely distributed in the Oregon Jurassic. He indicates segmentation in some of his forms, but it may be that this is accidental and due to imperfect preservation. The Oregon specimens are all without original segmentation, but, from mutilation, sometimes show what looks like it. There are apparently in the Oregon fossils two varieties, one the type of the species and the other a smaller form, which may

[a] Mr. Seward (Jur. Fl. Yorksh. Coast, p. 238) refers all these forms to *Ptilozamites* (*Ctenozamites*) *Leckenbyi* (Bean) Nath., and regards them as cycadaceous. They certainly simulate ferns in many respects, and it is proper that they stand first as being lowest in the grand division of seed-bearing plants.—L. F. W.

be regarded as a variety and called var. *minor*. The chief difference is in the lateral nerves.

There is a considerable difference in the size of the type forms. The largest attains a width of 4 cm. The length in no case is shown, as the specimens are all fragments of leaves. The longest fragment has a length of 8 cm. The smallest fragment is only 2 cm. wide. The leaf was apparently thin in texture, and the fossils are often found much puckered and lacerated. When the upper surface is presented uppermost, as is generally the case, a cord replaces the midnerve. In this cord the bases of the lateral nerves of the lamina of each side of the midrib are inserted. These nerves are very distinct, slender, and uniform in thickness from base to end. As a rule, their bases are inserted at equal distances, and the nerves go strictly parallel to one another in their course to the margin of the leaf. Usually they are rather remote, being about three for every 2 mm. of interval. They are inserted nearly at a right angle and curve slightly toward the tip of the leaf. Very rarely, and as it were by accident, a nerve forks, and sometimes in the same fashion two adjacent ones go off from the same point of insertion. Such a pair may unite halfway up in the lamina and go to the margin as a single nerve. These features are clearly not essential; although only fragments of leaves were obtained, their mode of narrowing indicates that they were not long, and were in form elongate-elliptical, obtusely rounded off at their bases and summits.

Pl. XVI, Fig. 3, gives, poorly preserved, a fragment which is the longest that was found. Fig. 4 gives with better preservation a somewhat wider leaf in a fragment from the middle part. Fig. 5 shows a fragment of a medium-sized leaf from the middle part, only the lamina on one side being preserved, and showing a laceration that imitates original segmentation. Fig. 6 is a small fragment from the middle part of a medium-sized leaf. Fig. 7 gives a fragment from the middle part of one of the smallest leaves, and Fig. 8 a portion of this enlarged. Fig. 9 shows the puckering and laceration that imitates another kind of original segmentation.

The plant occurs most abundantly at locality No. 18, but is found also at localities Nos. 1, 2, 7, 8, 14, 16, and 17.

NILSONIA ORIENTALIS MINOR Fontaine n. var.

Pl. XVI, Figs. 10–13.

As a rule, the leaves of the plant here called *Nilsonia orientalis minor* are decidedly smaller than those of the type, but the largest may equal the smallest of the original species—that is, they may attain the width of 2 cm. A nearly entire leaf of average size was found, which shows that the variety *minor* was about 8 cm. long and 15 mm. wide. The form was probably oblong elliptical, with subacute tips. The lateral nerves are proportionally stronger than those of the species and somewhat closer, being two to the millimeter, otherwise they are as in the species. Heer, on pl. iv, fig. 5, of the work quoted (supra, p. 151), gives a form that in shape and size resembles the variety now in question. Fig. 8 of the same plate may belong to this variety, for Heer indicates that the plant represented in it and in fig. 5 had closer nerves than the type.

Pl. XVI, Fig. 10, gives a nearly entire medium-sized leaf, and Fig. 11 shows the summit of this enlarged. Fig. 12 shows the greater part of one of the smallest leaves. Fig. 13 represents a fragment of the middle part of one of the largest leaves.

The plant occurs most commonly at locality No. 7, and is also found at localities Nos. 1, 2, 6, 8, and 19.

NILSONIA PARVULA (Heer) Fontaine n. comb.

Pl. XVII, Figs. 1–7.

1876. *Tæniopteris parvula* Heer: Fl. Foss. Arct., Vol. IV, Pt. II, p. 98, pl. xxi, figs. 5, 5b.

Heer has described from the Jurassic of Siberia a small tæniopteroid plant with the name *Tæniopteris parvula*, which is almost certainly the same as a plant that is very abundant at some of the Oregon localities. Heer obtained only a single small bit of a leaf 5 mm. wide, and naturally could not determine its true nature. The large number of well-preserved specimens from Oregon show that the fossil is a Nilsonia, belonging to the unsegmented kind. A midrib is sometimes shown, and sometimes its place is taken by the cord characteristic of the Nilsonias. This is according as the under or upper surface of the plant is presented uppermost. The leaves vary much in width. In

proportion to their width they are extraordinarily long. They must have been pendulous. They range in width from 2 mm. or 3 mm. to 10 mm. Very few attain the latter width. Most of them are from 5–7 mm. wide. Their length is unknown. It may be estimated by the fact that one specimen was found 125 mm. long, widening gradually until it attained the width of 7 mm. Usually the change in width is imperceptible in short fragments, and they look like blades of grass. The midrib, when visible, is in the larger leaves proportionally quite wide and flat. In all it is proportionally strong. The lateral nerves are of the usual kind in the entire Nilsonias, and they are in this species well defined, but are too fine to be seen in most cases without the help of a lens. This is on account of the thick leaf substance, which differs in that respect from *N. orientalis*. None of them were seen to fork. The leaf shows no trace of segmentation, and is remarkably free from accidental laceration, imitating segmentation.

The wider forms of this plant much resemble the fossil called by Yokoyama *Nilsonia ozoana*,[a] but the nerves are not strictly at right angles and are stronger. Besides, there is no possibility of separating them from the narrower forms.

Pl. XVII, Fig. 1, represents the longest specimen found. It gives a good idea of the extreme slenderness of the leaves, for at its widest end it is only 7 mm. wide. It is a portion of what was a much longer leaf, which probably did not have anywhere a width much above 7 mm. The specimens represented in Figs. 2 and 3 both occur on the same rock fragment with the plant depicted in Fig. 1. In Fig. 2 a fragment of medium size is represented. Fig. 3 gives a small portion of one of the narrowest leaves. Fig. 4 gives a portion of one of the commonly occurring smaller leaves, and Fig. 5 shows a portion of this enlarged. Fig. 6 shows a fragment of one of the largest leaves, a kind not often found. This in width approaches the smaller forms of *Nilsonia orientalis minor*, but is a much longer leaf. A portion of this is shown enlarged in Fig. 7.

The plant is exceedingly abundant at localities Nos. 2, 6, and 19, thickly covering faces of the rock. It is very abundant at No. 4, and is also found at Nos. 7 and 15.

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[a] Yokoyama, Jurassic plants from Kaga, etc.: Journ. Coll. Imp. Univer. Japan, Vol. III, Pt. I, pp. 41–42, pl. x, figs. 2b, 11–14.

NILSONIA NIPPONENSIS Yokoyama.

Pl. XVII, Figs. 8–10.

1889. *Nilsonia nipponensis* Yok.: Journ. Coll. Sci. Imp. Univ. Japan, Vol. III, Pt. I, p. 42, pl. vi, fig. 8d; pl. xii, fig. 6; pl. xiii, fig. 1.

Several specimens of a plant were found at localities Nos. 2 and 14 that agree closely with Yokoyama's *Nilsonia nipponensis*, except that the segments are not quite so much rounded off on the posterior margins of the ends. Yokoyama's specimens, however, seem to be somewhat distorted, and even this unimportant difference may be accounted for in that way. It is probable that several of the forms from the Jurassic of Siberia, called by Heer Ptèrophyllum and Anomozamites, belong to the same species. Their segments agree exactly in form, and the appearance of the midrib may be due to the fact that the lower surface of the plant is presented uppermost. The forms alluded to are *Anomozamites Schmidtii* and *Pterophyllum Helmersenianum*. The segments of this plant are broad and short. The nerves are slender, but sharply defined. They are simple and parallel to one another and to the margins of the segments.

The fragment given in Pl. XVII, Fig. 8, is apparently from the middle part of a leaf. Fig. 9 shows several segments of this enlarged. Fig. 10 shows the basal part of a leaf and illustrates the tendency to irregularity of the segments in this part of the leaf. The segments on opposite sides of the midrib are quite unequal in width, and at the end of the fragment the segments are succeeded by a narrow lamina on each side that is entire. The midrib of this specimen has great strength.

NILSONIA COMPTA (Phillips) Göppert.

Pl. XVII, Figs. 11–14.

1828. *Pterophyllum Williamsonis* Brongn.: Prodrome, pp. 95, 199 (nomen).[a]
1829. *Cycadites comptus* Phill.: Geology of Yorkshire, pp. 148, 189, pl. vii, fig. 20.
1833. *Pterophyllum comptum* (Phill.) L. & H.: Foss. Fl. Gt. Brit., Vol. I, p. 187, pl. lxvi.

[a] As no description or figure ever accompanied the use of this name it may, although antedating all others, be dropped as a nomen nudum; still, as Brongniart in his Tableau, 1849, distinctly enters it as a synonym of *Nilsonia compta*, and as numerous authors (Morris, Göppert, Unger, etc.) have introduced it into the literature, it can not well be omitted from the synonymy.—L. F. W.

1844. *Nilsonia compta* (Phill.) Göpp.: Uebersicht d. Arbeiten d. Schles. Ges. f. Vaterl. Kultur, 1843, p. 139.

1870. *Pterozamites comptus* (Phill.) Schimp.: Pal. Vég., Vol. II, p. 147.

Several specimens of a plant were obtained from localities Nos. 7 and 19 that seem to be identical with the fossil called by Lindley and Hutton *Pterophyllum comptum*,[a] which is now regarded as a Nilsonia. The Oregon specimens, in the shape of their segments, agree best with Schenk's figure of this species.[b] The specimens are poorly preserved and show only small portions of the leaves. The segments vary in size. They are oblong in form, slightly falcate and obtuse at the ends, with the posterior margins of the ends more curved than the anterior, so as to produce a narrowing at the ends. From distortion some of them seem to be wider at their bases, but are not really so. The lateral nerves are slender but distinct. They go off nearly at a right angle, are parallel to one another, and single. They curve slightly forward toward the ends of the leaves. The longer segments are 15 mm. in length, but they vary in length and width. The average width is about 6 mm. The smaller segments do not surpass 10 mm. in length and 4–5 mm. in width. Some of the basal segments are abnormally wide, as if from consolidation of two adjacent ones, but this is evidently not an essential feature. This heteromorphous form in basal segments seems to be a common feature in cycadaceous leaves segmented after the fashion of Pterophyllum. Such segments are shown in Pl. XVII, Fig. 14.

Pl. XVII, Fig. 11, shows the smaller form of the Oregon plant, and Fig. 12 a single segment enlarged. Fig. 13 represents the larger form. This specimen is somewhat distorted in the ends of the segments, so that they appear wider at their bases. Fig. 14 represents a fragment from the basal part of a leaf.

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[a] Foss. Fl. Gt. Brit., Vol. I, pp. 187–190, pl. lxvi.

[b] Schenk, Pflanzliche Versteinerungen aus Richthofen's China, Vol. IV, p. 262, pl. liv, fig. 2b.

Nilsonia pterophylloides Nathorst non Yokoyama.

Pl. XVIII.

1878. *Nilssonia pterophylloides* Nath. [non Yok.[a]]: Foss. Fl. vid Bjuf, Hft. I, p. 11 (nomen).

1879. *Nilssonia pterophylloides* Nath. [non Yok.]: op. cit., Hft. II, p. 72, pl. xvi, fig. 1; pl. xvii, figs. 2, 3.

Several specimens of a plant were obtained from the Oregon Jurassic strata that seems to be identical with the *Nilsonia pterophylloides* of Nathorst, occurring in the Rhetic of Sweden. Nathorst's forms, however, seem to be rather larger than those from Oregon. Yokoyama has described from Japan, with the name *Dioonites Kotoei*,[b] a similar form, which, although smaller than the Oregon type, seems to be essentially the same and to be a Nilsonia rather than a Dioonites. It is true that Nathorst shows his leaflets as going off at an acute angle, whereas the Oregon forms have leaflets that are inserted at nearly or quite a right angle. But all of these are distorted, and the true angle of insertion may be different, or Nathorst's plants may show the leaflets of the upper part of the leaf, while in the Oregon specimens they may belong to the lower portions, where, as is common in segmented leaves of this type, the segments make a larger angle with the axis than they do in parts nearer the ends of the leaves. Only fragments of leaves, rather poorly preserved, were obtained. Judging from the specimens, the leaflets were inserted by the entire, not widened, bases of the upper face of the axis. They are linear in form, widest in the lower portion, and narrowing gradually toward the end. The ends in no case were preserved, so that their true nature can not be determined, and their full length is not known. The leaf texture seems to have been thin. In some of the specimens, owing to distortion just above the bases of the leaflets, the bases appear wideñed. The greatest length of leaflet seen is 65 mm., the tips not being preserved. The width near the base of the widest leaflet is 5 mm. The nerves are about 7 in number. They are inserted at the same angle as the leaflets, are single, and of equal

[a] Yokoyama in 1894 named a form from the Mesozoic of Japan *Nilssonia pterophylloides* as a new species (Journ. Coll. Sci. Imp. Univ. Japan, Vol. VII, Pt. III, 1894, pp. 207, 228, pl. xxii, figs. 8–10; pl. xxv, fig. 7). It proves to be the *Nilsonia californica* Font. of the Shasta group. See p. 252.—L. F. W.

[b] Journ. Coll. Sci. Imp. Univ. Japan, Vol. III, Pt. I, pp. 44–45, pl. vii, figs. 1abc, 1e; pl. xiv, fig. 14.

strength from near their bases to their ends. They are distinctly defined, but slender.

Pl. XVIII, Fig. 1, shows the largest specimen seen, in which the leaflets are considerably distorted, none being entire. The narrowing above the bases of the leaflets, due to distortion, causes the bases to appear too wide. Fig. 2 gives leaflets of the smallest size, they being shown on only one side of the rachis. Fig. 3 shows four of the segments enlarged. Fig. 4 gives a fragment of a leaf with the longest leaflets seen. Fig. 6 is an enlargement of one of them. Most of them are narrower than common and are distorted in width from pressure, but some seem originally to have been wider than the rest. Fig. 5 gives parts of some of the widest leaflets in which the base and apex are not preserved.

The plant occurs rarely at localities Nos. 2, 7, and 19.

Genus PTEROPHYLLUM Brongniart.

PTEROPHYLLUM NATHORSTI Schenk.

Pl. XIX, Figs. 1–6.

1883. *Pterophyllum Nathorsti* Schenk: Pflanliche Versteinerungen aus Richthofen's China, Vol. IV, p. 261, pl. liii, figs. 5, 7.

Schenk has described with the name *Pterophyllum Nathorsti* a fossil from the Jurassic of China that agrees closely with an important plant in the Oregon beds. The plant is exceedingly abundant at some of the localities and the large number of specimens obtained give a good idea of its character. The leaf was evidently quite long in proportion to its width, but in all cases it was small. Most of the Oregon forms are rather smaller than the two given by Schenk, but specimens can be selected that equal these in size. The leaves were linear elliptical in shape, wider in the central portion, and, from the shortening of the segments, narrowing toward the base and apex. The longest fragment seen is 85 mm. long, without showing the base and tip. In this the longest segments are in the upper end, showing that this was near the middle of the leaf. These segments are about 7 mm. long, so that the entire leaf was about 17 cm. long and 15 mm. wide in its middle portion. The leaves apparently had a petiole. The leaf substance was pretty

thick, for it leaves a film of coal, and the lateral nerves of the segments are usually hidden. The axis of the leaf is quite strong and rigid in proportion to the dimensions of the segments or leaflets. The leaflets on different leaves in the same positions vary a good deal in length and width and in the proportion of length to width. They are, as stated, always shorter toward the ends of the leaves, and toward the base are often proportionally wider. Sometimes in that position they are markedly irregular in form, the width being abnormally great. In describing the leaflets we must take the average or more common forms found toward the central portions of the leaves. The leaflets are attached nearly or quite at a right angle, by their entire bases, which are of the same width as the main portion of the leaflet. They are linear with parallel sides. The attachment is to the sides of the midrib or axis of the leaf. They are slightly falcate, but may be straight. The tip is obtuse and rounded off, but narrowed somewhat by the posterior margin curving forward. The nerves of the leaflets are few in number, 5–7, and slender, being generally not visible without the help of a lens. They are attached at the same angle as the leaflets, and are parallel to one another and to the margins of the leaflets. They are not forked, and are of equal strength from their insertions to their ends. The average leaflets are about 8 mm. long and 2 mm. wide. They may, however, be only 3 mm. long and 1 mm. wide.

The plant has in the form of the leaflets a resemblance to the two fossils figured by Lindley and Hutton as *Pterophyllum pecten* (Phill,) L. & H.[a] and *Zamia taxina* L. & H.[b] It resembles the latter more closely, but the leaflets are mostly smaller and closer. It has the leaflets much closer than the former.

Pl. XIX, Fig. 1, gives the largest fragment seen. It shows well the increase in the length of the leaflets in ascending from the base, and the greater width of the basal ones. Fig. 2 gives a fragment of the middle portion of a leaf having average leaflets, and Fig. 3 shows a portion of this enlarged. Fig. 4 represents a fragment from a similar part of the leaf, with narrower leaflets. Fig. 5 gives a basal portion of a small leaf. Fig. 6 shows a fragment of the middle part of a leaf, with wider and shorter leaflets than usual. In these the nerves are rather more remote than is common. They are 5 in number.

[a] Foss. Fl. Gt. Brit., Vol. II, pp. 61–62, pl. cii.

[b] Op. cit., Vol. III, p. 67, pl. clxxv.

The plant is very abundant at locality No. 7, and is here only inferior in quantity to *Pterophyllum rajmahalense*. (See p. 102.) It is very abundant at locality No. 4 and is common at locality No. 2. It occurs at localities Nos. 8, 12, and 19.

Pterophyllum contiguum Schenk.

Pl. XIX, Figs. 7–11.

1883. *Pterophyllum contiguum* Schenk: Pflanliche Versteinerungen aus Richthofen's China, Vol. IV, p. 262, pl. liii, fig. 6.

The fossil from the Jurassic of China, described by Schenk as *Pterophyllum contiguum*, seems to be the same as a plant that is not rare at some of the Oregon localities. Schenk seems to have had only one specimen and could not determine its full character. The Oregon specimens are fragments mostly of the middle portions of leaves. The midrib is very strong and rigid in proportion to the size of the leaflets. The leaflets are quite thin in texture. They are linear in form, of the same width from base to apex; not falcate, but straight. They are very obtuse at their ends and symmetrically rounded off there. They stand at right angles to the rachis. Their form is much like that of the leaflets of *P. æquale*, but they are mostly narrower. They vary a good deal in size, being in some cases almost as small as the smallest of the leaflets of *P. Nathorsti*. The average leaflet is about 2 cm. long and a little more than 2 mm. wide. The smallest forms are somewhat less than 10 mm. long and 2 mm. wide. These are rare. Schenk shows the leaflets as simply touching one another, but in many of the Oregon forms they not only touch but seem to be united, so as to show between two adjacent leaflets what looks like a strong nerve or cord. This may be simply a line of the rock matter squeezed between the adjacent leaflets. The distinguishing character of the plant is the constant close approximation of the leaflets. The nerves are slender, and to be seen require the help of a lens. They are about 5 in number, simple, and parallel to one another and to the margins of the leaflets.

Pl. XIX, Fig. 7, gives a portion of the middle part of a leaf carrying leaflets of the largest size, and Fig. 8 shows a portion of this enlarged. Fig. 9 shows a similar part of a leaf with leaflets of the narrowest kind, and Fig. 10 a portion of the same enlarged. Fig. 11 represents a poorly preserved portion of a leaf with the narrowest leaflets.

The plant is most common at locality No. 7, where it is abundant. It is also found at localities Nos. 4 and 19.

Pterophyllum æquale (Brongniart) Nathorst.

Pl. XX.

1825. *Nilsonia ? æqualis* Brongn.: Ann. Sci. Nat. Paris, Vol. IV, p. 219, pl. xii, fig. 6.
1828. *Pterophyllum dubium* Brongn.: Prodrome, p. 95.
1838. *Zamites æqualis* (Brongn.) Presl in Sternberg: Flora der Vorwelt, Vol. II, p. 198.
1841. *Ptilophyllum æquale* (Brongn.) Morr.: Ann. & Mag. Nat. Hist., Ser. I, Vol. VII, p. 117.
1878. *Pterophyllum æquale* (Brongn.) Nath.: Foss. Fl. vid. Bjuf, Hft. I, p. 11 (nomen); K. Svensk. Vet.-Akad. Handl., Vol. XVI, No. 7, pp. 18, 48, pl. ii, fig. 13; pl. vi, figs. 8–11.

Nathorst has given from the Rhetic of Sweden, with the name *Pterophyllum æquale*,[a] two forms that seem to me to belong to different species. The plant figured in his Floran vid Bjuf, Heft II, pl. xv, fig. 11a, as *P. æquale rectangulare* seems to be identical with *P. rajmahalense*[b] from India. This I infer from the fact that the true *P. æquale* and *P. rajmahalense* are both abundant in the Oregon flora, and are quite constant in character, with differences sufficient to denote that they are different plants. It is true that a few forms are intermediate between the two, but they are exceptions, and not sufficient to establish a passage of one form into the other. In plants of this type there could not be a variation in the size of the leaflets without approaching the one or the other type, and in the great number of specimens that were obtained they are to be expected. They should be interpreted not as true passage forms, but rather as aberrant and accidental. It is possible to select in the many specimens a few forms that would make a passage from the largest of the *rajmahalense* type to the most minute of the *P. Nathorsti* leaves.

The leaf substance of *P. æquale* is thinner than that of *P. rajmahalense*. The rachis is comparatively slender. No entire leaves were seen. The leaflets are long in proportion to their width, appearing slender, and contrasting in that point with those of *P. rajmahalense*. They are linear, with the margins parallel to each other, and are mostly slightly falcate.

[a] Floran vid Höganäs, p. 18, pl. ii, fig. 13, pp. 48–49, pl. vi, figs. 8–11; Floran vid Bjuf, pp. 67–68, pl. xv, figs. 6–10.

[b] Oldham and Morris, Foss. Fl. of the Rajmahal Series, p. 25 (Foss. Fl. Gondw. Syst., Vol. I), pl. xiii, figs. 3, 4, 5; pl. xiv, fig. 2; pl. xviii, fig. 2.

They are attached by the entire base to the sides of the axis of the leaf, nearly or quite at a right angle. The width is the same from the base to near the tip, where they are usually slightly narrowed, so that they have elliptic terminations. They are generally not very closely placed. They vary somewhat for different leaves in length and width, and in the same leaf become shorter toward the base and probably toward the end. No ends were seen. Taking the leaflets from near the middle part of the leaf as the normal ones for description, the average length may be put at 25 mm. and the average width at 3–4 mm. As extreme variations we may have in similar parts leaflets 35 mm. long and 6 mm. wide for the maximum size and 10 mm. long and 3 mm. wide for the minimum. The variation is mainly in length. Nathorst in his diagnosis of the species says that the nerves of the leaflets are mostly dichotomous at base. In the Oregon specimens they may be dichotomous at or near their bases, but they are mostly single, especially in the smaller forms. They are parallel to one another and slender, not being easily seen without the help of a lens. They do not vary much in strength from their base to their ends, and are 10–12 in number.

Pl. XX, Fig. 1, gives a portion of what seems to have been the middle part of a leaf, with leaflets of maximum size. The terminations of most of them are not shown. Fig. 2 shows a fragment of a similar part of a leaf carrying narrower leaflets, but of a length equal to that of those given in Fig. 1. This large form is quite common at locality No. 2 and is mostly missing elsewhere. It is strikingly like *P. Jægeri* Brongn. of the Trias. Fig. 3 is an enlargement of two of the leaflets of Fig. 2. Fig. 4 shows the middle part of a smaller form with leaflets still rather wider than the average. Fig. 5 gives a fragment of a leaf with leaflets that may be taken as average ones. Fig. 6 shows the middle part of another leaf with average-size leaflets. Fig. 7 shows the upper part of one of the leaves with the smallest leaflets.

The plant is most common at locality No. 7, where the average and smaller forms are found. The larger forms are abundant at locality No. 2, to the exclusion of others. It occurs also at localities Nos. 1, 4, and 19.

PTEROPHYLLUM RAJMAHALENSE Morris.

Pl. XXI, Figs. 1–7.

1863. *Pterophyllum rajmahalense* Morr. in Oldham & Morris: Foss. Fl. Gondw. Syst., Vol. I, p. 25, pl. xiii, figs. 3–5; pl. xiv; pl. xviii, fig. 2.

1876. *Pterophyllum Sensinovianum* Heer: Fl. Foss. Arct., Vol. IV, Pt. II (Jura-Fl. Ostsibiriens), p. 105, pl. xxiv, fig. 8.

The plant regarded as *Pterophyllum rajmahalense* is one of the most important and characteristic of the Oregon Jurassic fossils. Hundreds of specimens were collected at some of the localities. Many of them are well preserved and a larger portion of the leaf is often obtained than is found in the case of most of the plants of the region. Hence all parts of the leaf are well represented. The leaves do not seem to have been long. They are remarkably compact and strong. The largest fragment seen is 18 cm. long. The base and apex are missing. It indicates a leaf, exclusive of the petiole, about 25 cm. long, and this may be taken as about the maximum length. The leaf substance must have been very thick and leather-like, for a strong film of coal is left. The leaf is narrowly elliptical and widest near the middle, narrowing gradually toward the base and apex. It is terminated by a pair of leaflets that are abruptly diminished in size. The axis or midrib is strong. One is 5 mm. wide, having a petiole of considerable length. This is shown only partially when preserved. The leaflets vary a good deal in size in the same leaf and in different ones. The variation is chiefly in width, the length remaining remarkably constant in similar parts of different leaves. They are always quite wide in proportion to their length. Occasionally one or two aberrant forms, wider or narrower, are located in the midst of normal forms. They are usually closely placed. In very rare cases their margins touch. In one case the leaflets appear to be consolidated. They are on different sides of the axis, mostly opposite. They become shorter toward the base and apex. There is a marked tendency to aberrant forms in the basal leaflets. The lowest ones are often much wider than the others, as if two adjacent ones had become consolidated. These then look like leaflets of *Nilsonia nipponensis*. They are attached by the entire base to the sides of the axis at a right angle and are perfectly straight, with no tendency to a falcate shape. They are oblong, with parallel margins, and of the same width from base to apex. The tips vary somewhat. In the most com-

mon form the leaflet maintains its width to the end, where it is rounded off with a semicircular curve. They are sometimes truncate. In the rarer cases the tip is narrowed by being rounded off obliquely on its posterior terminal margin. The average leaflets from the middle portion of the leaves may be taken as having a length of 18 mm. and a width of 5 mm. Those of maximum size from the same part of the leaf may attain a length of 20 mm. and a width of 8 mm. The smallest leaflets from similar parts are 15 mm. long and 4 mm. wide. The nerves are very fine and rarely visible. They can be seen distinctly only with the help of a lens. They are attached at a right angle to the axis, are parallel to one another, and not forked. They vary somewhat in number according to the width of the leaf. About 15 may be taken as the average, but 17 or more may occur. They do not vary in strength from one end to the other. Most of the forms given by Oldham and Morris from the Indian Rajmahal series are larger than the average forms from Oregon, but the Rajmahal Pterophylla generally show a remarkable robustness.

This plant was found in the Oroville flora[a] in a few specimens forming an important connecting link between that and the Oregon Jurassic. Heer describes from the Jurassic of Siberia a fossil that he names *Pterophyllum Sensinovianum.*[b] This seems to be the same as the plant now in question. He separates it from *P. rajmahalense* because it has fewer nerves, but he says the nerves are obsolete, and, as he had in hand only one small fragment, it is not probable that he saw all the nerves. In the hundreds of specimens found in Oregon only a few show the nerves distinctly enough to count them.

Pl. XXI, Fig. 1, shows the lower portion of a leaf with leaflets of medium size. Fig. 2 is an enlarged portion of Fig. 1. Fig. 3 gives a similar part of another leaf, with short, wide leaflets, the lowest ones abnormally wide, and also a portion of the petiole. Fig. 4 gives the terminal part of one of the smallest leaves, showing the two end leaflets abruptly much reduced in size. These are enlarged in Fig. 5. Fig. 6 gives the basal part of a leaf carrying leaflets of the greatest width, and showing an abnormal widening of the basal ones. Fig. 7 shows nearly an entire leaf with leaflets of the largest size.

[a] Twentieth Ann. Rep. U. S. Geol. Surv., Pt. II, 1900, p. 354, pl. lvi, figs. 4, 5.
[b] Fl. Foss. Arct., Vol. IV, Pt. II, p. 105, pl. xxiv, fig. 8.

The plant occurs with an immense number of imprints at locality No. 7, where it stands next to the Ginkgos in number. It is found also at localities Nos. 1, 4, 14, and 19.

Pterophyllum minus Brongniart?

Pl. XXI, Figs. 8, 9.

1825. *Pterophyllum minus* Brongn.: Ann. Sci. Nat. Paris, Vol. IV, p. 219, pl. xii, fig. 8.[a]

Several specimens of a small plant that is much like the *Pterophyllum minus* figured by Lindley and Hutton[b] are found at locality No. 7. The plant is somewhat smaller than the form figured in Fossil Flora, but is of the same type. The leaflets are about 5 mm. long and 3 mm. wide. They are closely placed, touching by their edges. They are at right angles to the midrib and of equal width from base to tip. The ends are truncate or slightly rounded. The nerves are about 12 in number, single, perpendicular to the midrib, and parallel to one another. They are slender and can be seen only obscurely, even with a lens. The plant sometimes approaches the wider forms of *Pterophyllum Nathorsti*. It may be a Nilsonia, but a strong midrib is always shown. The amount of material is too small and too poorly preserved to permit positive identification with the plant of Lindley and Hutton.

Pl. XXI, Fig. 8 shows the specimen natural size and Fig. 9 the upper part enlarged.

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[a] Professor Fontaine does not refer to this figure nor cite this memoir, and Mr. Seward also ignores it. It is an obscure and little-known paper, but important as being the one in which the genera Pterophyllum and Nilsonia were first named. The plates of the early volumes of the Annales are difficult to find, being in quarto form and usually bound up in atlases that cover several volumes of the text. They are wanting in many libraries and are generally overlooked by bibliographers. The plants were from the Rhetic of Hör in Scania, but Lindley and Hutton identified a Yorkshire Oolitic form with this species, and it is their figure that Professor Fontaine refers to. Lindley and Hutton give the name *Pterophyllum Nilsoni* to another figure on the same plate, identifying it with the *Asplenioptcris Nilsoni* ? figured by Phillips in his Geology of Yorkshire, 1829, pl. viii, fig. 5, which in turn was supposed by him to be probably the plant so named by Sternberg in his Flora der Vorwelt, Vol. I (Tentamen, p. xxii, also index and index iconum), pl. xliii, figs. 3–5, but which he first (fasc. IV, 1825, p. 40) called *Asplenium Nilsonii*. Mr. Seward, without mentioning these early figures of Brongniart and Sternberg or their types, has used Sternberg's name (crediting it to Phillips) and grouped a large number of forms under the combination "*Anomozamites Nilssoni* (Phillips)." Professor Fontaine, after receiving his Jurassic Flora of the Yorkshire Coast, and fully weighing the question, declines to follow him in this, and prefers to retain the name *Pterophyllum minus*.—L. F. W.

[b] Foss. Fl. Gt. Brit., Vol. I, pp. 191–192, pl. lxvii, fig. 1.

Genus CTENOPHYLLUM Schimper.

CTENOPHYLLUM ANGUSTIFOLIUM Fontaine.

Pl. XXII.

1896. *Ctenophyllum angustifolium* Font.: Am. Journ. Sci., 4th ser., Vol. II, p. 274 (nomen.).

1900. *Ctenophyllum angustifolium* Font.: Twentieth Ann. Rep. U. S. Geol. Surv., 1898–99, Pt. II, p. 360, pl. lxiii, figs. 2, 3.

Ctenophyllum angustifolium was found for the first time in the Oroville flora, in which only two imperfect specimens were seen. This fossil is quite abundant in the Oregon Jurassic flora at locality No. 2, where a number of fairly good specimens were obtained. The characters made out in the Oroville specimens are seen in those from Oregon. While the latter are much larger, they do not show the bases and tips of any of the leaves, which still remain unknown. The leaves must have had a considerable size, for fragments 8 cm. long were obtained that indicate that, without the petiole, they must have been at least 15 cm. long. The leaves seem to have been oblong elliptical in form, narrowing to the base and apex. The axis is strong. The leaflets seem to have had a different angle of attachment according to their position on the leaf. They were, in the basal portion, perpendicular to the axis. In the higher parts they become more and more inclined. They were usually somewhat falcate, more so in the upper parts of the leaf. The leaf substance was thick and dense. They are slightly expanded where the base is attached, and keep their width unchanged to above the middle of the leaflet, then narrow gradually to the tip. They are very narrow and linear in form. The tips are obtusely rounded off. In the same position on the leaf they may vary somewhat in width, a few being a little wider or narrower. Taking the leaflets from the middle portions of the leaves for measurement, there is some small variation in different leaves. The widest leaflets seen did not have their ends preserved. They have a width of 3 mm. The narrowest leaflets are only 2 mm. wide. The longest leaflet seen, probably not actually the longest, is 6 cm. long and 2 mm. wide near the base. The leaflets are rather remotely placed. The nerves are slender, and not easily seen without the help of a lens. They are unbranched, attached at the same angle as the leaflets, and about 5 in number.

Pl. XXII, Fig. 1 shows a form with the widest leaflets; Fig. 2 gives a fragment showing the greatest length of leaflets in leaves of average width, and Fig. 3 a few of these enlarged a little; Fig. 4 shows a pretty large fragment with leaflets of the narrowest kind; Fig. 5 includes two fragments with leaflets of average width, having some irregular in size.

The plant is quite common at locality No. 2, and occurs also at locality No. 1.

CTENOPHYLLUM PACHYNERVE Fontaine n. sp.

Pl. XXIII, Figs. 1–4.

A plant regarded as a new species of Ctenophyllum was found, with several specimens, in the Oregon flora. It has some resemblance to *Ctenophyllum grandifolium Storrsii*,[a] but is a much smaller plant. The variety *Storrsii*, in the description of the Oroville flora, was erroneously drawn, with anastomosing nerves. The species now in question is rare, and the specimens are mostly poorly preserved, but it has such a distinct character that it differs certainly from any previously described form. The midnerve or axis of the leaves is not well shown, but seems to be slender. The leaflets vary somewhat according, apparently, to their position on the leaves. They are attached by their entire base to the sides of the axis. Apparently they stand at right angles to the axis in the lower portion of the leaves and are there straight. In the upper parts of the leaves they are inclined to the axis at angles more acute as the ends of the leaves are approached. In these positions they are slightly falcate. All are linear in form, widest in the lower part, and narrow toward their tips, having obtuse ends. In some of the specimens distortion has caused the insertion of the leaflets to appear somewhat widened, which is not really the case. The upper leaflets are more closely placed than the lower ones. The latter are sometimes quite remote. The upper falcate leaflets are the only ones showing their full length. They are 5 cm. long and 4 mm. wide. The leaf substance was thick and leather-like. The most characteristic feature is seen in the nerves of the leaflets. These are 5-7 in number, attached under the same angle as the leaflets, mostly single and parallel to one another. They are peculiarly strong and stand out like threads, causing the leaflets to appear striated. In the upper falcate leaflets no

[a] Twentieth Ann. Rep. U. S. Geol. Surv., Pt. II, 1900, p. 359, pl. liii, fig. 3; pl. lxii; pl. lxiii, fig. 1; pl. lxvi, fig. 3.

forking was seen in the nerves; in the lower ones a nerve occasionally forks above the point of insertion.

Pl. XXIII, Fig. 1, gives a considerable portion of the upper part of a leaf with obliquely placed leaflets. Fig. 2 represents a fragment of the basal part of a leaf containing the basal portion of some remote, narrow leaflets. Fig. 3 shows a similar part of a leaf carrying the basal parts of several larger and more closely placed leaflets. Fig. 4 shows two of these leaflets enlarged.

The plant is rare everywhere. It is most common at localities Nos. 18 and 19.

Ctenophyllum Wardii Fontaine.

Pl. XXIII, Figs. 5–12.

1896. *Ctenophyllum Wardii* Font.: Am. Journ. Sci., 4th ser., Vol. II, p. 274 (nomen).
1900. *Ctenophyllum Wardii* Font.: Twentieth Ann. Rep. U. S. Geol. Surv., 1898–99, Pt. II, p. 357, pl. lix; pl. lx; pl. lxvii, fig. 5.

A considerable number of specimens of a plant that agrees well with *Ctenophyllum Wardii* were found at some of the Oregon localities. They are very fragmentary, and do not compare with the fine specimens found in the Oroville flora. Nearly all the specimens are fragments of unattached leaflets, poorly preserved. The midrib indicated on the Oregon plants seems wider than that seen in the Oroville specimens, for one shows a width of 5 mm. The leaflets have about the same range in width as those of Oroville. The widest have a width of about 2 cm. and the narrowest about 1 cm. The nerves are numerous, fine, and closely placed. They are prominent, and not immersed in the leaf substance, but stand out like threads. They fork mostly at their base, and sometimes, but rarely, higher up. Some are single. Very rarely an anastomosis may be detected, but it is clearly not an essential feature.

Fig. 5 shows parts of several leaflets evidently once united to a common midrib, and Figs. 6 and 7 are enlargements of two of these. Fig. 8 includes portions of two large leaflets, probably of their middle parts. Fig. 9 gives part of a small leaflet. Fig. 10 shows part of a midrib and several attached fragments of leaflets shown on only one side of the midrib. Fig. 11 shows a fragment of the upper part of a leaf with portions of several leaflets attached. Fig. 12 is an enlargement of Fig. 11.

It occurs at localities Nos. 1, 2, 7, 11, 17, and 19.

Genus PODOZAMITES Friedrich Braun.

Podozamites pulchellus Heer.

Pl. XXIV, Figs. 1–10.

1876. *Podozamites pulchellus* Heer: Fl. Foss. Arct., Vol. IV, Pt. I (Beitr. z. Foss. Fl. Spitzbergens), p. 38, pl. ix, figs. 10, 11a, 12b, 13, 14.
1876. *Zamites* sp. Heer in part: op. cit., p. 39, pl. viii, fig. 9.

At several of the Oregon localities a good many detached leaves occur that in size, shape, and nervation agree exactly with the fossil from the Jurassic of Siberia, described by Heer as *Podozamites pulchellus*. I am not sure that this is a cycad and that it is not some broad-leaved conifer like Dammara. Heer gives the principal nerves as parallel, and converging toward the base and apex of the leaflets, and states that between each pair of the stronger ones there is a more slender one that runs parallel with them. He also says that the surface of the leaflets is covered with raised points. The latter feature was not seen in the Oregon specimens. The nerves have exactly the character given by Heer for the stronger ones, and sometimes traces of finer nerves may be seen between them. In most cases none of the nerves are visible, owing to the thick leather-like nature of the leaf, which often appears shining, as if polished. The leaflets vary a good deal in size and somewhat in shape, but in the latter point they are more constant. They are elliptical or ovate-elliptical in form and widest near the middle. The tip is generally acute and is sometimes prolonged. The width varies in proportion to length, some being more narrowly elliptical than others. They are usually rounded off at base and do not show any indication of being attached by a petiole. The figures given will show the variations. There is in many of the leaflets a seeming midnerve, but a careful examination shows that this is due to a puckering of the leaflets along the axial line. In a number this appearance is not shown. The nerves are about 10 in number. They are simple, parallel to one another and to the margins of the leaflets, and converge toward one another in the base and apex of the leaflets.

Pl. XXIV, Fig. 1, gives, not complete, one of the longest leaflets seen, which has a seeming midnerve. Fig. 2 shows this enlarged. Fig. 3 represents a nearly entire leaf of the broadly elliptical kind, which shows the nerves rather distinctly, and between them traces of the fine nerves. This is enlarged in Fig. 4. Fig. 5 gives one of the ovate-elliptical leaflets,

with a prolonged tip. Fig. 6 shows a narrowly elliptical entire leaf, with an apparent midnerve. Fig. 7 gives a part of one of the smallest broadly elliptical forms, with the tip not prolonged, showing a seeming midnerve. Fig. 8 shows one of the small narrowly elliptical leaflets. Fig. 9 is an enlargement of this. Fig. 10 represents two of the smallest leaflets, having a very narrow elliptical shape, and showing a seeming midnerve.

The plant is rare everywhere, and is most common at locality No. 7. It is found also at localities Nos. 1, 16, 17, and 19.

PODOZAMITES PACHYPHYLLUS Fontaine n. sp.

Pl. XXIV, Figs. 11–16.

The plant here considered as forming a new species of Podozamites is found in the form of detached leaflets and fragments of leaflets at several of the Oregon localities. It is rare, and the specimens are mostly not well preserved. Still, enough is shown to indicate that the plant is a pretty well characterized new species. Its true position, however, must remain doubtful. It agrees well enough with Podozamites to be placed in that genus.

The leaflets are linear in form and narrow toward their bases, after the fashion of Podozamites. They narrow also somewhat toward their tips, which are obtusely rounded off. They have a remarkably thick and leather-like texture and stand out in films of coal on the rock. The widest of them is 6 mm. wide in its widest part. The longest seen, which were not quite entire, are 6 cm. long. The bases are not well enough preserved to show the probable mode of attachment. Several of the leaflets seem to show the true base, and to indicate that they were narrowed to about half the average width of the leaflet, and were attached by the narrowed portion. The nerves are 7 to 10 in number and are characteristic. They are approximately parallel to one another and to the margins of the leaflets. They are mostly single, but a few branch once, on entering the wider part of the leaflet above the base. They seem to differ in strength, the central ones being stronger; at least in many cases the central ones are much more distinct than those nearer the margins, and sometimes can be plainly seen where the others are not visible. The leaflet then looks as if it had only 2 or 3 nerves running up its middle. This suggests an affinity with Torreya, but the marginal nerves are really present, although not so distinct. This is the case with the thickest leaflets. This plant

resembles the leaflets given by Phillips as *Pterophyllum rigidum*,[a] but its leaflets are not narrowed so much toward their tips. They are also like Heer's *Podozamites obtusifolius*,[b] so named on the plate, but described as *Baiera longifolia* Pomel spec. (*Dicropteris longifolius* Pom.). The plant is probably nearer to Nathorst's *Pterophyllum ? cteniforme*,[c] from the Rhetic of Sweden, and possibly may be identical with it.

Pl. XXIV, Fig. 11 gives portions of two leaflets in a position to indicate that they were attached to the same midnerve. One of them that is almost entire shows a length of 6 cm. Fig. 12 shows parts of several thick leaflets that were probably attached to the same axis. These show the greater strength of the central nerves. Fig. 13 shows the tips of several leaflets corresponding to those given in Fig. 12. Fig. 14 represents a nearly entire leaflet in which the base seems to be preserved. Fig. 15 shows this enlarged. Fig. 16 gives a nearly entire leaflet of the smallest kind, with the base apparently preserved.

The plant is always rare, but is most common at locality No. 7. It occurs also at localities Nos. 1, 18, and 19.

PODOZAMITES LANCEOLATUS (Lindley & Hutton) Friedrich Braun non Emmons.

Pl. XXIV, Figs. 17–20.

1836. *Zamia lanceolata* L. & H.: Foss. Fl. Gt. Brit., Vol. III, p. 121, pl. cxciv.
1840. *Zamites lanceolatus* (L. & H.) Fr. Br.: Verzeichn. Kreis-Nat.-Samml. z. Bayreuth, p. 100.
1843. *Podozamites lanceolatus* (L. & H.) Fr. Br. (non Emm.) in Münster: Beitr. z. Petrefacten-Kunde, Vol. II, Pt. VI, p. 33.
1847. *Zamites distans longifolia* Fr. Br.: Flora, Vol. XXX, p. 85 (nomen).
1867. *Zamites distans longifolia* Fr. Br. Schenk: Foss. Fl. d. Grenzsch., p. 162, pl. xxxvii, fig. 1.
1876. *Podozamites lanceolatus genuinus* Heer: Fl. Foss. Arct., Vol. IV, Pt. II (Jura-Fl. Ostsibiriens), p. 108, pl. xxvi, fig. 10.[d]

There are in the Oregon Jurassic flora a number of leaflets and fragments of leaflets that agree with some of the forms united in the species

[a] Geology of Yorkshire, 3d ed., p. 228, lign. 57.

[b] Fl. Foss. Arct., Vol. IV, Pt. I, pl. viii, fig. 6 (cf., p. 39).

[c] Flor. vid. Bjuf, Hft. II, p. 69, pl. xiv, fig. 1.

[d] Heer has caused much confusion by giving this combination to the type form of Lindley and Hutton, especially as Schenk applied the name *Zamites distans genuina* to a closely related form, and the names *distans* and *lanceolatus* are constantly interchanged; but Heer's *Podozamites lanceolatus genuinus* is Friedrich Braun's *Zamites distans longifolia*, accepted by Schenk, and both, according to Heer, are the *Zamia lanceolata* of Lindley and Hutton.—L. F. W.

Podozamites lanceolatus. None of them are attached, and as they are often not well preserved, their true position can not be regarded as positively fixed. There has been, most probably, a union of too many forms under the general name *Podozamites lanceolatus*, as in the case of *Cladophlebis whitbiensis*, and it is possible that some of them are broad-leaved conifers. A few scattered leaflets that agree pretty well with the normal *lanceolatus* type occur in the Oregon strata.

Pl. XXIV, Fig. 17 gives a nearly entire leaf, which has the tip missing, and is by pressure distorted so as to appear convex. Fig. 18 gives the greater part of a narrower leaflet. Fig. 19 shows the greater portion of a large leaflet with the base well preserved. This is rounded and broader than the upper part of the leaflet. It may be a leaflet of *Zamites gigas* (L. & H.) Carr. It is shown enlarged in Fig. 20.

The forms occur very rarely at localities Nos. 2, 7, 17, and 18.

PODOZAMITES LANCEOLATUS MINOR (Schenk) Heer.[a]

Pl. XXV, Figs. 1–4.

1867. *Zamites distans minor* Schenk: Foss. Fl. d. Grenzsch., p. 162, pl. xxxv, fig. 10.
1870. *Podozamites distans minor* (Schenk) Schimp.: Pal. Vég., Vol. II, p. 159.
1876. *Podozamites lanceolatus minor* (Schenk) Heer: Fl. Foss. Arct., Vol. IV, Pt. II (Jura-Fl. Ostsibiriens), p. 110, pl. xxvii, figs. 5a, 5b, 6–8.

Several detached leaflets, nearly entire, were obtained that agree very well with Heer's *Podozamites lanceolatus minor*. The leaflets are thin in texture, small in size, and narrowed gradually toward the base and apex. The nerves are not distinctly shown, but seem to be numerous and closely placed.

Pl. XXV, Fig. 1, shows a nearly entire leaflet, enlarged in Fig. 2. Fig. 3 gives a fragment of a much smaller one, of which Fig. 4 is an enlargement.

The leaflets are very rare. They are most common at locality No. 7, but occur also at locality No. 2.

[a] I give in the synonymy only those references which are designated by the varietal name *minor*, although Heer expressly states that the form figured by Ettingshausen as the true *Zamites distans* of Presl (Abh. k.-k. geol. Reichsanst., Vol. I, Abth. III, No. 3, 1852, pl. i, fig. 3) from the Rhetic of Bayreuth and Veitlahn is the same as those from the Oolite of the upper Amoor. But a comparison of the original figure of Z. *distans* in Sternberg's Flora der Vorwelt, Vol. II, 1838, pl. xli, fig. 1, reveals the greatest similarity to that of Ettingshausen. It is also practically identical with Schenk's *Z. distans minor* (Fl. d. Grenzsch., pl. xxxv, fig. 10), nearer, I think, than his *Z. distans genuina* (op. cit., pl. xxxvi, figs. 1–3), which he seems to regard as the type. The group is in great need of revision.—L. F. W.

PODOZAMITES LANCEOLATUS LATIFOLIUS (Friedrich Braun) Heer.[a]

Pl. XXV, Figs. 5–7.

1840. *Zamites latifolius* Fr. Br. non (Brongn.) Presl: Verzeichn. d. Kreis-Nat.-Samml. z. Bayreuth, p. 100 (nomen).
1847. *Zamites distans latifolia* Fr. Br.: Flora, Vol. XXX, p. 85 (nomen).
1867. *Zamites distans latifolia* Fr. Br. Schenk: Foss. Fl. d. Grenzsch., p. 162, pl. xxxvi, fig. 10.
1870. *Podozamites distans latifolius* (Fr. Br.) Schimp.: Pal. Vég., Vol. II, p. 159.
1876. *Podozamites lanceolatus latifolius* (Fr. Br.) Heer: Fl. Foss. Arct., Vol. IV, Pt. II (Jura-Fl. Ostsibiriens), p. 109, pl. xxvi, figs. 5, 6, 8b, 8c.

Three specimens of broad leaflets, not attached, that agree very well with Heer's variety *latifolius*,[b] were obtained, two from locality No. 19, and one from locality No. 7. The leaf texture seems to have been quite thick, so that the nerves are not visible.

Pl. XXV, Fig. 5, shows a nearly entire leaflet of medium size, of which Fig. 6 is an enlargement. Fig. 7 gives two leaflets, one of the largest and one of the smallest size.

PODOZAMITES? PACHYNERVIS Fontaine n. sp.

Pl. XXV, Fig. 8.

Fig. 8 gives a problematic form that may be a Zamites. It occurs at locality No. 2 in the form of a fragment of a leaflet, with the base and apex not preserved. As it narrows toward the base after the fashion of Podozamites it may be placed provisionally in that genus. The single specimen found does not suffice to fix its character. It is noteworthy for the very strong nerves that stand out on the surface like threads. They are about 10 in number, and diverge on entering the wider portion of the leaflet near the base, and then become parallel. They are unbranched.

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[a] I was probably in error in the first paper (p. 36) in including the *Tæniopteris latifolia* of Brongniart from the Oolite of Stonesfield, England, in the synonymy of this species. Sternberg first referred it to Odontopteris, and Presl to Zamites, as there stated; but no one seems to have followed Presl in this, and Brongniart in his Tableau (1849) adheres to his original determination and has been generally followed. There is no evidence that Friedrich Braun had Brongniart's plant in mind in naming his *Zamites latifolius* (1840), which he made a variety of *Z. distans* in 1847, the name adopted by Schenk when he reelaborated the Rhetic material in 1870. Heer referred all the forms of *Z. distans* that he found in the Oolite of Siberia to *Podozamites lanceolatus* (*Zamia lanceolata* L. & H.), using Schenk's varietal names in some cases, but not consistently.—L. F. W.

[b] Fl. Foss. Arct., Vol. IV, Pt. II, p. 109, pl. xxvi, figs. 5, 6, 8b, c.

Genus CTENIS Lindley and Hutton.

CTENIS SULCICAULIS (Phillips) Ward n. comb.[a]

Pl. XXV, Fig. 9; Pl. XXVI.

1828. *Zamia longifolia* Brongn.: Prodrome, pp. 94, 199 (nomen).
1829. *Cycadites sulcicaulis* Phill.: Geology of Yorkshire, pp. 148, 189, pl. vii, fig. 21.
1834. *Ctenis falcata* L. & H.: Foss. Fl. Gt. Brit., Vol. II, p. 63, pl. ciii.
1841. *Zamites longifolius* (Brongn.) Morr.: Ann. & Mag. Nat. Hist., 1st Ser., Vol. VII, p. 116.
1864. *Pterophyllum falcatum* (L. & H.) Sandberger [non Nath.]:[b] Verh. d. Naturw. Ver. in Karlsruhe, Heft I, p. 35 [6].

A number of specimens of this fine plant were obtained. Unfortunately the stratum which contains most of them has no cleavage and tends to break across the plane of the leaves. Hence the specimens procured are smaller than the parts contained in the rock. The figures given by Zigno[c] of this plant very accurately represent it as found in the Oregon strata. I do not find, however, on the axes, the regular reticulation given in Zigno's Fig. 1a. The marking on the axes is an irregular wrinkling or puckering of the epidermis, seen only when that is present. The axes seem to be very robust, but the amount of vascular tissue is not so great as might be supposed from its width. They were apparently succulent, with a large proportion of cellular tissue. The apparent width is increased also by the continuation, over the axis, of the thick epidermis of the base of the leaflets. The leaves must

[a] The name *Ctenis falcata* L. & H. certainly can not stand. Lindley and Hutton themselves state that it is the *Cycadites sulcicaulis* of Phillips, of which that author gives a fair figure in his Geology of Yorkshire (1829). That Lindley and Hutton had better material and made a better figure is no reason for changing a name, as this would permit anyone at any time to make a new name if better material were discovered. The name *Zamia longifolia* of Brongniart, given by Mr. Seward (Jur. Fl. Yorksh. Coast, p. 235) may be ignored as a nomen nudum, no description or figure of it having ever been published either under that name or under the name *Zamites longifolius*, first used by Morris in 1841, and later by Brongniart himself in his Tableau (pp. 62, 106). The fact that Mr. Seward found in the Paris Museum a specimen labeled *Zamia longifolia* belonging to this species is scarcely sufficient to justify giving this specific name to the plant. If it had been the type, so designated by Brongniart in his Prodrome, or even on the label, it might have been accepted under some codes, as, for example, that of the Ornithologists' Union, Canon XLIII, p. 53; but Mr. Seward does not say that the label was in Brongniart's handwriting, and, moreover, the specimen was found at Cayton near Scarborough, while Brongniart (Prodrome, p. 199) gives Whitby as the locality. All things considered, therefore, it does not seem possible to adopt Brongniart's name, and it must become a synonym.—L. F. W.

[b] This combination is usually credited to Schimper (Pal. Vég., Vol. II, p. 137), who does not mention Sandberger's paper. The *Pterophyllum ? falcatum* Nath., Fl. v. Bjuf, Hft. II, p. 71, pl. xiii, figs. 16, 17 (1879), whatever it may be, is a preoccupied name and must be changed.—L. F. W.

[c] Flor. Foss. Form. Oolith., Vol. I, pp. 190–192, pl. xxiv, figs. 1–3.

have been very large. A fragment was obtained 15 cm. long, and this was evidently but a small part of the leaf, for the axis shows no diminution throughout its length. The fragments of several leaves are commonly found together, indicating that they were associated in growth. The leaflets in the upper part of the leaves seem to have been more closely placed, and to be proportionally wider than those in the lower part. The leaves had a petiole of considerable length. The widest axis seen is about 6 mm. in width. The longest leaflets obtained are 10 cm. long. They show no diminution in width and are evidently much shorter than the entire leaflet. There is not much variation in the width of the leaflets. The widest are 10 mm. in width and the narrowest are 6 mm. The Oregon specimens have suffered much from the creep of the rock which contains them. This has taken place along the plane of the leaves and left them polished and much puckered and distorted. The wrinkles sometimes resemble reticulated nerves. The leaflets are widest at base and are decurrent. They are attached by the entire base and curve strongly away from the axis. They are strap-shaped. The nerves are sharply defined, but slender, and are immersed in the leaf substance, which is comparatively thin. They are approximately parallel and do not anastomose so copiously as Zigno represents them. The magnified figure of Lindley and Hutton[a] gives much more nearly the reticulation as seen in the Oregon forms. They run parallel for long distances, sending off short branches that unite very obliquely with the adjacent nerves. The anastomosis takes place at pretty regular intervals, first at the base of the leaflets, then higher up, at intervals of a little less than 10 mm.

Pl. XXV, Fig. 9, shows portions of three leaves, two with petioles, and all so placed as to indicate that they were associated in growth. Pl. XXVI, Fig. 1, shows the largest specimen found, which is apparently the middle part of a leaf. This is shown enlarged in Fig. 2. It is much distorted. Fig. 3 gives portions of two leaves, with broad leaflets. Fig. 4 shows a portion of the upper part of a leaf with wide leaflets. Fig. 5 shows a fragment of a leaf with the narrowest leaflets found. They are shown enlarged in Fig. 6.

The plant is abundant at locality No. 19, and occurs rarely at localities Nos. 1, 2, 3, 7, and 17.

[a] Foss. Fl. Gt. Brit., Vol. II, pp. 63–64, pl. ciii.

Ctenis orovillensis Fontaine.

Pl. XXVII, Figs. 1–5; Pl. XXVIII, Fig. 1.

1896. *Ctenis orovillensis* Font.: Am. Journ. Sci., 4th ser., Vol. II, p. 274 (nomen.).
1900. *Ctenis orovillensis* Font.: Twentieth Ann. Rep. U. S. Geol. Surv., 1898–99, Pt. II, p. 357, pl. lviii, fig. 4.

This splendid plant was found in the Oroville flora. A considerable number of specimens were obtained from some of the Oregon localities, which make it possible to add something to the description of its character. The Oregon specimens show the leaflets more completely. The leaves must have been very large, as is indicated by the fragment depicted in Fig. 141, which is the largest found. This is a good deal distorted and mutilated, so that it does not show the exact mode of attachment of the leaflets, as they are toward their bases most imperfect. The figure represents the upper part of a leaf, showing the upper leaflets with their bases very near the axis, but not attached to it. If their attitude is not distorted they must, in this portion of the leaf, have gone off under an acute angle. One of the leaflets in a lower position is nearly entire and will give an idea of the size. Though not entire, it is still 17 cm. long, and near its base is 2 cm. wide. These dimensions are found in what is probably an average leaf, and they indicate a length of 20 cm. In this specimen all the leaflets are distorted in their basal portions. The leaf substance appears to have been quite thin in proportion to the size of the leaflets. The terminal part of the leaflets was narrowed so as to give the entire leaflet a saber form. The nerves are rather remote and are approximately parallel. They are slender, but sharply defined, and immersed in the leaf substance. They anastomose rather rarely and irregularly, by sending off a branch which unites with an adjacent nerve at a very acute angle.

Pl. XXVII, Fig. 1, gives the most complete specimen found. Fig. 2 shows one of the leaflets enlarged. Fig. 3 shows the base of a leaflet, indicating its mode of attachment. This is slightly enlarged in Fig. 4. Fig. 5 gives what seems to have been the upper part of a leaf. It has the basal parts of several leaflets attached to the midrib, but the attachment is obscured by distortion. Pl. XXVIII, Fig. 1, shows the basal parts of several leaflets, so placed as to indicate a former attachment to

a common midrib. It is not certain that these belong to the plant in question. If they do they belong to the upper part of a leaf.

The plant is not common. It is most abundant at locality No. 7. Several specimens were found at locality No. 2.

Ctenis grandifolia Fontaine

Pl. XXVIII, Figs. 2–8.

1896. *Ctenis grandifolia* Font.: Am. Journ. Sci., 4th ser., Vol. II, p. 274 (nomen.).
1900. *Ctenis grandifolia* Font.: Twentieth Ann. Rep. U. S. Geol. Surv., 1898–99, Pt. II, p. 354, pl. liii, fig. 2; pl. lvi, figs. 6, 7; pl. lvii.

Several specimens of a plant much like *Ctenis grandifolia* were obtained from the Oroville localities. This plant was found in the Oroville flora. The Oregon specimens do not add anything to the character made out from the Oroville plants. They are much too distorted and mutilated. Only fragments were found. From these neither the shape nor the size of the leaflets can be determined. The attachment seems to have been by the whole of a somewhat expanded base, which in one specimen seems to be decurrent, but this is probably due to distortion. The leaflets in the Oregon specimens apparently sometimes had great width, equaling 5 cm. The narrowest had near the base a width of about 25 mm. The nerves are quite remote, strong, and sharply distinct, but they are immersed in the leaf substance. They are approximately parallel and anastomose rather freely at long intervals, in the same manner as those of *Ctenis orovillensis*.

Pl. XXVIII, Fig. 2, shows the most complete specimen, but it is greatly distorted. A portion of the midrib remains, and to this the three leaflets still preserved were formerly attached. But the attached parts are not now visible. The leaflets indicate a width of 5 cm. They are doubled upon themselves along the middle line of their length, owing to being crushed down into the rock. Fig. 3 gives the basal part of a fragment of a wide leaflet, showing nerves rather vaguely. A small portion of this is shown enlarged in Fig. 4. Fig. 5 represents a fragment of the narrowest form of leaflet with the base preserved and showing the mode of attachment, but probably distorted so as to cause an apparent decurrence. Fig. 6 shows the basal portion of this

enlarged. Figs. 7 and 8 show a fragment 4 cm. wide, indicating the nerves quite well.

The plant is not abundant. It is most common at locality No. 7. It occurs more rarely at localities Nos. 2, 9, and 18.

CTENIS AURICULATA Fontaine?

Pl. XXIX, Fig. 1.

1896. *Ctenis auriculata* Font.: Am. Journ. Sci., 4th ser., Vol. II, p. 274 (nomen.).
1900. *Ctenis auriculata* Font.: Twentieth Ann. Rep. U. S. Geol. Surv., 1898–99, Pt. II, p. 356, pl. lviii, figs. 1–3.

At locality No. 7 a single specimen of a large Ctenis was obtained that agrees quite well with *C. auriculata*, a plant first found in the Oroville flora. The preservation is not perfect enough to make the identification positive. A portion of the midrib was obtained having on one side the basal parts of two leaflets, one pretty well preserved. This is 5 cm. long and 3 cm. wide at base. It is attached apparently by all of an unnarrowed base, which is not auriculate. The leaf substance was very thin and left very little coal on the rock. The nerves are strong, very remote, single at their bases, but anastomose freely about 15 mm. above their bases—more freely than in the Oroville specimens. It may be a new species.[a]

Genus ENCEPHALARTOPSIS Fontaine.

ENCEPHALARTOPSIS ? OREGONENSIS Fontaine n. sp.

Pl. XXIX, Figs. 2, 3.

A single fragment of a leaflet, with resemblance to those of Encephalartos, was found at locality No. 4. It is of doubtful affinity and is mentioned because it certainly differs from the other cycads of the Oregon flora. It is narrowly linear, narrowing gradually toward its end. It has a thick, dense texture, which gives it a very rigid aspect. Apparently it had a firm, almost horny epidermis. It must have had a considerable length, for the part preserved, though a small portion of the original leaf, still shows a length of 6 cm., with a maximum width of 4 mm. It had spiny points going off at long intervals and turning

[a] The specimen was on two pieces of rock, one the counterpart of one-half of the leaf shown on the other. In the latter the leaf was folded on both sides of a thin slab, the rachis running along the thin edge. The figure (Pl. XXIX, Fig. 1) shows the frond unfolded and gives a fair idea of its nature.—L. F. W.

strongly away from the leaflets. These are now preserved only in their lower portions. The nerves are single, strong, parallel, and vaguely shown.

Genus CYCADEOSPERMUM Saporta.

CYCADEOSPERMUM OREGONENSE Fontaine n. sp.

Pl. XXIX, Fig. 4.

A single specimen of a small nut-like seed was found at locality No. 2. It seems to be the seed of some cycad. It is hard and bony, with a smooth polished surface. It is elliptical in form and narrows to both ends, one of which is rounded off, while the other is somewhat prolonged into a short acute tip. It is widest in the middle and is there 6 mm. wide. The length is 10 mm.

CYCADEOSPERMUM OVATUM Fontaine n. sp.

Pl. XXIX, Fig. 5.

A single specimen of a small nut was obtained from locality No. 7. It is apparently the seed of some cycad. It has a hard, bony, and smooth surface. It is widest at its base and is rounded off there. It narrows to the opposite end, which is obtuse. At this end there is a ridge which runs up a little way into the body of the nut. This may be due to puckering from pressure, causing a wrinkle, but this is not probable. The nut is 10 mm. long and 6 mm. wide at base.

Order BENNETTITALES.

Family BENNETTITACEÆ.

Genus WILLIAMSONIA Carruthers.

WILLIAMSONIA OREGONENSIS Fontaine n. sp.

Pl. XXIX, Fig. 6.

A single fine specimen of the inflorescence of a Williamsonia was found at locality No. 7. There is nothing to show a connection between this plant and the numerous cycads found at that locality. On the same piece of rock, however, a well-preserved fragment of *Pterophyllum æquale* (Brongn.) Nath. occurs. The fossil is large and globular in form, showing a whorl of bracts incurved so as to hide any object within them. The bracts are thick in texture and without any midnerve,

linear in form with obtuse ends. The globular inflorescence is broader than long, having a width of 5 cm. and a height or length of 35 mm. It is quite convex and stands well out from the rock. The inflorescence is borne on the summit of a stout peduncle, showing a length of 35 mm., being obviously not entire. The entire width is not preserved. The portion shown is 15 mm. wide. This seems to have been largely composed of cellular tissue, and to have been succulent. In general form the bracts resemble those of *Williamsonia gigas* (Willn.) Carr., as given by Saporta in fig. 2, pl. xvi, Vol. IV of the Plantes Jurassiques, but they are not so long as those of Saporta, and do not taper at all toward their tips.

WILLIAMSONIA ? sp. Fontaine.

Bract of WILLIAMSONIA No. 1.

Pl. XXIX, Fig. 7.

A thick, fleshy object resembling a leaf was obtained from locality No. 7. It is a good deal distorted and has at present an ovate shape. It is somewhat convex from pressure, and on casual inspection looks somewhat like a nut. It was, however, too soft for this to be the case. It is broadest at base and tapers ovately to the tip, which is obtuse. The base shows traces of an original cordate shape. At about the center of the basal margin there is a rounded depression that looks as if the object had been joined to its support by articulation. The fossil looks more like the bract of the involucre of some form of Williamsonia.

WILLIAMSONIA ? sp. Fontaine.

Bracts of WILLIAMSONIA ? No. 2 (*a*, *b*, *c*).

Pl. XXIX, Figs. 8–12.

Three objects were found at locality No. 19 that at first sight might seem to be nut-like seeds. They are, however, most probably thick, fleshy bracts or leaves, and appear to belong to the inflorescence of some Williamsonia. Although, as shown on the rock, they are slightly convex, they are not enough so for a nut-like seed, and besides they show evidence of having been too soft for such objects. The leaf substance is represented by a film of coal of considerable thickness, which, however, is not always present, having been stripped off. The slate under this coal film shows a distinct nervation, which is not visible on the

leaf substance. This indicates that the nerves are disclosed only on the lower surface. The nervation resembles that of Neuropteris of the Carboniferous, but there is no midnerve visible, although it may be present, as the nervation is not fully disclosed. The nerves appear to radiate from the base of the fossil, and they fork several times. The surface of the coal film, which represents the supposed bract, is granulated with minute papillæ of no definite form. They may be due to the shrinking of the leaf. The general aspect of these fossils suggests that they may be bracts of the involucre of some Williamsonia. The three found are apparently essentially the same, but present some unimportant differences in form, which are shown in the figures given. They are distinguished as *a*, *b*, *c*.

Bract *a* is elliptical in form and not symmetrical, one lateral margin being more strongly convex than the other. It tapers gradually to a subacute tip, which is well shown. The base is imperfect. Bract *b* is of the same general form, but is broader and proportionally shorter. The basal portion is wanting. Bract *c* is ovate elliptical and nearly symmetrical in form.

Pl. XXIX, Fig. 8, represents bract *a*, enlarged in Fig. 9; Fig. 10 bract *b*, and Fig. 11 bract *c*, enlarged in Fig. 12.

Order GINKGOALES.

Family GINKGOACEÆ.

Genus GINKGO Kaempfer.

The Ginkgos of the Oregon Jurassic are the most important fossils in it. This is due to the fact that they show a great number of specimens and a very considerable variety of forms, which are quite well preserved. The leaves are preserved mostly entire, and the condition in which they may be obtained depends on the splitting of the rock containing them. Unfortunately the cleavage of this is generally poor, otherwise very perfect specimens might be obtained in greater numbers. At some of the localities the imprints of Ginkgo leaves are exceedingly numerous and may be obtained by the hundreds. The faces of the rock, when exposed by splitting it, are covered with numerous impressions, often of different character or type, while the variation in the leaves is considerable. I am not sure that they are not all modi-

fications of the rather polymorphous species *Ginkgo digitata* (Brongn.) Heer. The limits of variation in the same species, for leaves of the Ginkgo type, are not fully known. Mr. Seward and Miss Gowan, in their paper on *Ginkgo biloba*,[a] have shown that the living Ginkgo tree is capable of considerable variation in its leaves, and that some of these forms even resemble Jurassic types. While forms of the leaves of the same species may be selected that would show such a variation, the significance as fossils of these variant forms would be better understood if it were known what proportion in numbers they bear to the normal forms and in what number they would occur in a fortuitous collection of leaves produced by a fall from the same tree.

In the Oregon localities many portions of rock are covered with leaves of different types in about equal proportions, indicating that each type belonged to different trees, on which it was the predominant form of leaf. The greater number of the Oregon Ginkgo leaves may be brought under several types of previously described forms. But these may be connected by intermediate forms, which occur in considerable numbers. Most of the previously described types illustrated in the Oregon Ginkgos are those given by Heer for the Jurassic of Siberia. It will perhaps give a better idea of the Oregon forms if they are described as belonging to the previously described species, which they most resemble, treating under separate heads those that can not be thus grouped.

GINKGO DIGITATA (Brongniart) Heer.

Pl. XXX, Figs. 1–7.

1829. *Sphænopteris latifolia* Phill. [non Brongn.][b] Geology of Yorkshire, pp. 148, 189, pl. vii, fig. 18.

1830. *Cyclopteris digitata* Brongn.: Hist. Vég. Foss., Vol. I, p. 219, pl. lxi bis, figs. 2, 3.

1836. *Adiantites digitatus* (Brongn.) Göpp.: Syst. Fil. Foss., p. 217.

1843. *Baiera digitata* (Brongn.) Fr. Br. in Münster: Beitr. z. Petrefacten-Kunde, Vol. II, Heft VI, p. 21.

1865. *Cyclopteris incisa* Eichw.: Lethæa Rossica, Vol. II, p. 13, pl. iv, fig. 6.

[a] The maidenhair tree, by A. C. Seward and Miss J. Gowan: Annals of Botany, Vol. XIV, No. LIII, March, 1900, pp. 109–154, pl. viii–x.

[b] Brongniart's Carboniferous species *Sphenopteris latifolia* dates from the Prodrome (p. 51), one year earlier than this, which is therefore to be dropped, although antedating all other names for this plant.—L. F. W.

1874. *Ginkgo digitata* (Brongn.) Heer: Regel's Gartenflora, Jahgr. XXIII, p. 261, pl. dcccvii, figs. 1–4.
1874. *Ginkgo integriuscula* Heer: Regel's Gartenflora, Jahrg. XXIII, p. 261, pl. dcccvii, fig. 5.
1876. *Ginkgo digitata* (Brongn.) Heer: Fl. Foss. Arct., Vol. IV, Pt. I (Beitr. z. Foss. Fl. Spitzbergens), p. 40, pl. x, figs. 1, 5a b, 6.
1876. *Ginkgo digitata biloba* Heer: Op. cit., p. 41, pl. viii, figs. 1a, 1aa.
1876. *Ginkgo digitata quadriloba* Heer: Op. cit., p. 42, pl. x, figs. 3a, b.
1876. *Ginkgo digitata multiloba* Heer: Op. cit., p. 42, pl. x, fig. 2.
1876. *Ginkgo digitata angustiloba* Heer: Op. cit., p. 43, pl. x, fig. 4.
1876. *Ginkgo integriuscula* Heer: Op. cit., p. 44, pl. x, figs. 7–9.
1878. *Salisburia digitata* (Brongn.) Sap.: Plantes Jurassiques, Vol. III, p. 294, pl. clx [xxxii], figs. 1–5.
1881. *Ginkgo digitata integriuscula* (Heer) Kollbrunner: Jahresb. d. Ostschweiz-Geogr.-Comm. Ges. in St. Gallen, 1880–1881, pp. 62, 77.[a]

I will place with this species those leaves that have the following character, ignoring possible sporadic variation:

Leaf substance thin; leaves small, with a wide spread, being wider than long; segments numerous and not deeply incised, wide in proportion to their length, closely placed and widest near or at their ends, so that they have an obcuneate form; ends obtusely rounded, truncate, or slightly notched.

This type is represented in the Oregon Jurassic by a considerable number of specimens, but not by so many as some other types. They vary somewhat in size, but are all small in comparison with the forms of the *lepida* and *Huttoni* type. This type tends to pass into the *sibirica* type more than into any other.

Pl. XXX, Fig. 1, gives a nearly entire medium-sized leaf, showing a portion of its petiole. Two of the lobes of this are shown slightly enlarged in Fig. 2. Fig. 3 shows a part of the summit of one of the leaves having the most numerous segments. Fig. 4 represents a nearly entire leaf of the largest size. This is shown slightly enlarged in Fig. 5. Figs. 6 and 7 give a part of a leaf having the widest segments seen. This shows a portion of the petiole.

The *digitata* type of Ginkgo is pretty widely distributed in the Oregon Jurassic. It is found at localities Nos. 2, 7, 14, and 19.

[a] This may have been simply an error of Kollbrunner's in failing to observe that Heer gave this form specific rank. Bartholin in 1894 (Bot. Tidsk., Vol. XIX, pp. 96, 97, 108, pl. iv [xii], fig. 1), reduced it to a variety.—L. F. W.

GINKGO HUTTONI (Sternberg) Heer.[a]

Pl. XXX, Figs. 8–12; Pl. XXXI, Figs. 1–3.

1833. *Cyclopteris digitata* Brongn. Lindley & Hutton: Foss. Fl. Gt. Brit., Vol. I, p. 179, pl. lxiv.
1833. *Cyclopteris Huttoni* Sternb. Flora der Vorwelt, Vol. II, p. 66.
1836. *Adiantites Huttoni* (Sternb.) Göpp.: Syst. Fil Foss., p. 217.
1874. *Ginkgo Huttoni* (Sternb.) Heer: Regel's Gartenflora, Jahrg. XXIII, p. 261, pl. dcccvii, fig. 4.
1876. *Ginkgo Huttoni* (Sternb.) Herr: Fl. Foss. Arct., Vol. IV, Pt. I (Beitr. z. Foss. Fl. Spitzbergens), p. 43, pl. x, fig. 10.
1878. *Salisburia Huttoni* (Sternb.) Sap.: Plantes Juarassiques, Vol. III, p. 299, pl. clix [xxxi], figs. 4, 5; pl. clx [xxxii], fig. 8.
1900. *Ginkgo digitata* forma *Huttoni* (Sternb.) Sew.: Jur. Fl. Yorksh. Coast, p. 259, pl. ix, fig. 2.

The forms which I group under the specific name *Huttoni* are the most abundant next to those classed as *G. sibirica*. At some localities the *Huttoni* form is more abundant than any other. The leaf substance is thick and firm. The leaves have as a rule four segments, which often show no trace of subdivision. Occasionally one or more of the segments may be divided by comparatively slight incisions, and more commonly they may show a notching of the ends. The segments are very wide in proportion to their length. They are widest above the middle of the segment and generally narrow somewhat near the tip, which is rounded off or may be truncate. When the segments are more than four, the plant approaches the *digitata* type. Most of the leaves are larger than those given by Heer.[b]

A very large leaf of this type that is found in a good many specimens and is the most common Ginkgo at locality No. 2 may be a new

[a] Most authors include this form in *G. digitata*, which Lindley and Hutton believed it to be, but Sternberg separated it, redescribed it, and named it *Cyclopteris Huttoni*. Heer, however, retained it, as did also Saporta. Mr. Seward, in his Jurassic Flora of the Yorkshire Coast, reduces it to a mere form, of which he finds and figures a specimen from Scarborough in the British Museum, No. V, 3578. In the description of pl. ix, fig. 2, he does not separate it from *G. digitata*, but on page 259 he treats it as a form. After the arrival of his work in America I called Professor Fontaine's attention to this, and in his letter of August 21, 1901, from which I have already quoted extracts, says: "The Ginkgos gave me a good deal of trouble. There seemed to be no way of dealing with them except as I did, or making them all *G. digitata*. I think *G. Huttoni* as good a species as can be made out of such leaves. It is a common form, and very few specimens occur grading toward *G. digitata*." I therefore retain the species and confine the synonymy to those names that refer to Lindley and Hutton's plant.—L. F. W.

[b] Fl. Foss. Arct., Vol. IV, Pt. I, p. 40, pl. x, fig. 10; Pt. II, pp. 59–60, pl. v, fig. 1b; pl. vii, fig. 4; pl. x, fig. 8.

species. As, however, there is no marked difference except size to separate it, I will describe it as a variety of *G. Huttoni*, with the variety name *magnifolia*. The normal *Huttoni* leaves are much smaller.

Pl. XXX, Fig. 8, gives a normal leaf with segments of the most deeply cut kind. Fig. 9 shows this slightly enlarged. Figs. 10 and 11 represent one of the smaller leaves with broad segments. Fig. 12 gives one of the smaller leaves with proportionally longer segments, more elliptic in form. Pl. XXXI, Fig. 1, shows a leaf with very wide, short segments. Fig. 2 gives a portion of a leaf which has a greater number of segments than is common and which approaches the *digitata* type. It is shown slightly enlarged in Fig. 3.

The plant is most abundant at locality No. 7 and is common also at locality No. 2. It occurs not rarely at locality No. 19.

GINKGO HUTTONI MAGNIFOLIA Fontaine n. var.

Pl. XXXI, Figs. 4–8; Pl. XXXII, Figs. 1, 2.

The form distinguished as *Ginkgo Huttoni magnifolia* is pretty constant in character and, as stated, may really be a new species. The length of none of the leaves is preserved entire. The width may be made out very well from some of the specimens and the length may be estimated. It differs from *G. Huttoni* in the great width and length of the segments. As in *G. Huttoni*, they are normally four in number, and in general form they agree well with those of the specific type. Some of the leaves, as made out from the specimens, must have been 12 cm. wide in their widest part, and probably were 9 cm. from base to summit. The petiole is strong and very long. A portion of one was seen 6 cm. long. Some of the segments of the leaf were obtained from 25–30 mm. wide. The nerves are strong and rather remote.

Pl. XXXI, Fig. 4, shows the most complete leaf obtained of the smallest kind. It does not have the ends of the segments preserved. It retains a portion of the petiole, which shows the stoutness. The petiole and one of the sides are shown slightly enlarged in Fig. 5. Figs. 6 and 7 show a fragment that may give an idea of the length attained by the segments, although their tips are wanting. Fig. 8 shows a fragment of a leaf from which an idea of the great width of the segments may be obtained. Pl. XXXII, Figs. 1 and 2, give a fragment of a very large

leaf in which one side is entire, affording an idea of the width of the leaf. The summit of this is not preserved.

This plant is much the most common Ginkgo at locality No. 2, where it is abundant. It is also found at localities Nos. 4, 7, and 19.

GINKGO LEPIDA Heer.

Pl. XXXII, Figs. 3–8.

1876. *Ginkgo lepida* Heer: Fl. Foss. Arct., Vol. IV, Pt. II (Jura-Fl. Ostsibiriens), p. 62, p. vii, fig. 7; pl. xii.

1885. *Salisburia* (*Ginkgo*) *lepida* (Heer) Dn.: Trans. Roy. Soc. Canada, Sect. IV, Vol. III, p. 8, pl. ii, fig. 2.

The *lepida* type of Ginkgo, as given by Heer, is represented in the Oregon flora by a considerable number of specimens. The leaf substance is thick and leather-like. The primary segments are cut down to the base of the leaves, where they are reduced almost to petioles. The secondary segments are long and narrowly elliptical to linear in form, widest near the middle and tapering toward their lower and upper portions. This form sometimes tends to pass into the *sibirica* type by intermediate shapes that are rather common. The *lepida* type departs further than any other from that of *G. digitata*.

Pl. XXXII, Fig. 3, gives a nearly entire leaf and one of the largest found. It shows the long narrow segments well. This is shown enlarged in Fig. 4. Fig. 5 shows a primary segment with several ultimate ones, the basal part not being preserved. Fig. 6 denotes a primary segment with the base not preserved, having shorter and proportionally broader ultimate segments than is common. Fig. 7 shows this much enlarged. Fig. 8 gives a portion of a primary segment with three ultimate ones of the smallest size. Owing to the deep incisions of the leaf and its spreading habit, it is rare to find entire leaves of this type.

This plant is most common at locality No. 19, where it is rather abundant. It is also common at locality No. 7. It occurs more rarely at locality No. 4.

GINKGO SIBIRICA Heer.

Pl. XXXIII.

1876. *Ginkgo sibirica* Heer: Fl. Foss. Arct., Vol. IV, Pt. II (Jura-Fl. Ostsibiriens) pp. 61, 116, pl. vii, fig. 6; pl. ix, fig. 5b; pl. xi (excl. fig. 3b); pl. xx, figs. 3b, 6c; pl. xxii, fig. 3.

1885. *Salisburia* (*Ginkgo*) *sibirica* (Heer) Dn.: Trans. Roy. Soc. Canada, Sect. IV, Vol. III, p. 8, pl. ii, fig. 1.

Leaves.—Numerous specimens of Ginkgos occur in the Oregon flora that sometimes have the character of the form called by Heer *G. sibirica* and sometimes of his *G. Schmidtiana*,[a] the latter being a smaller leaf with a smaller number of segments; but these graduate so often one into the other, by commonly occurring intermediate forms, that there is no satisfactory way of separating them. I will therefore discuss them as one species. As the *sibirica* form is the most common, and apparently the type, I will regard them all as variations of *G. sibirica*. This Ginkgo is the most abundant and widely diffused type in the Oregon Jurassic, the leaves sometimes thickly covering the surface of the rock. If we neglect the intermediate shapes it is true we may select forms that are pretty widely separated, either as *G. sibirica* or as *G. Schmidtiana*. This is possibly what Heer did, not having so many specimens to illustrate the passage forms. In the description I will first note those belonging to *G. sibirica* proper and distinguish the smaller leaves as being of the *Schmidtiana* form. Possibly the latter may be immature leaves of the former. The normal or true *sibirica* type of Ginkgo in the Oregon Jurassic has the following character: The texture of the leaf is decidedly thinner than that of any of the other types except that of *G. Schmidtiana*. The leaves are small, being sometimes about the same size as those of *G. digitata*, but generally smaller. The segments of ultimate order are numerous, slender, and formed by a deep incision of the leaf, but not so deep as in *G. lepida*. These segments are narrowly elliptical or linear in form and widest near their middles, but do not vary much in width throughout their length.

Pl. XXXIII, Fig. 1, gives a portion of a leaf with numerous narrow segments. Fig. 2 shows the basal part of a medium-sized leaf, with a portion of the petiole well preserved. Fig. 3 gives one of the largest sized leaves, but in a fragmental condition. This is shown much enlarged in Fig. 4. Fig. 5 depicts a portion of a medium-sized leaf, with a central segment, well preserved. This is also shown much enlarged in Fig. 6.

[a] Fl. Foss. Arct., Vol. IV, Pt. II, p. 60, pl. vii, fig. 5; pl. xiii, figs. 1–2. I have not put *Ginkgo Schmidtiana* in the synonymy of *G. sibirica*, although Professor Fontaine clearly indicates that the Oregon forms embrace both of Heer's species and show all the necessary connecting links. As Heer described *G. Schmidtiana* on p. 60 and *G. sibirica* on p. 61 of his work, if they are consolidated the resulting species would, by the rules, become *G. Schmidtiana* and not *G. sibirica*. This may yet have to be done, but rather than do it I prefer to regard the species as distinct, and the American forms approaching *G. Schmidtiana* as representing the range of variation of the polymorphous species *G. sibirica*.—L. F. W.

Fig. 7 gives the terminal part of a leaf well preserved. The *Schmidtiana* type is, as stated, a smaller leaf, also with thin texture and with fewer ultimate segments, often with only four, otherwise the character is much like that of the normal *G. sibirica*. The *Schmidtiana* forms are not so abundant as those of *G. sibirica*, and they occur in the same localities. Fig. 8 gives one of the *Schmidtiana* leaves having the narrowest ultimate segments, and showing a portion of the petiole. Fig. 9 gives one of the largest leaves of this type, with the widest segments. It is shown considerably enlarged in Fig. 10. Fig. 11 shows the basal portion of a leaf, with medium-sized segments.

Seeds.—There are in the collections made at the Oregon localities a number of small nut-like seeds that seem to be the seeds of some Ginkgo. They are broadly ovate in form, and in size and shape agree exactly with the seeds attributed by Heer[a] to *Ginkgo sibirica*. These seeds vary but little in form and size. It is quite probable that they are in fact the seeds of *Ginkgo sibirica*, as the leaves of that species often occur with them. The leaves of other species occur with them also. They vary slightly in size and width, some being more narrowly elliptical than others.

Fig. 12 gives one of the smallest and most narrowly elliptical forms, shown enlarged in Fig. 13. Fig. 14 shows two small elliptical seeds, also enlarged in Fig. 15. Fig. 16 denotes one of average size and shape, enlarged in Fig. 17. Fig. 18 gives one of the largest and the most broadly elliptical seeds obtained, enlarged in Fig. 19.

These seeds are most abundant at locality No. 7. They occur at localities Nos. 14, 18, and 19.

GINKGOS OF ABERRANT FORMS.

Ginkgo sp. Fontaine.

Pl. XXXIV, Figs. 1–12.

Under this head I place certain Ginkgo leaves that do not plainly come under any of the previously described forms. They probably do not belong to any distinct species, but are aberrant leaves of some of the species described in the preceding pages. I note them in order

[a] Fl. Foss. Arct., Vol. IV, Pt. II, pp. 61–62, pl. xi, figs. 13–17.

that some idea may be formed of the numerous variations occurring in the Oregon Ginkgos. I do not give all that might be selected.

Pl. XXXIV, Fig. 1, shows a very small leaf with segments only at the summit of the leaf, shown enlarged in Fig. 2. They are not fully preserved. This leaf has some likeness to the small leaf given by Seward on pl. ix, fig. 8, of his Jurassic Flora of the Yorkshire Coast, and named *Ginkgo whitbiensis* Nathorst. The segments are not so long and acute as those of Yorkshire, but they are not well preserved. It occurs at locality No. 7. Figs. 3 and 4 (enlargement) give a very small leaf with three elliptic segments, occuring at the same locality. Figs. 5 and 6 (enlargement) give a larger leaf, hardly at all segmented, found also at locality No. 7. Figs. 7 and 8 (enlargement) denote a small leaf with four broad irregular segments. This also occurs at locality No. 7. Figs. 9 and 10 (enlargement) represent another form found at locality No. 7. It is a petiole, bearing at its summit a pair of small leaves with three segments each. Figs. 11 and 12 (enlargement) show a form from locality No. 18 that contains three narrow segments at the summit of a slender petiole. It resembles the form figured by Seward, op. cit., pl. ix, fig. 4, and named *Baiera Phillipsi* Nath.

Genus PHŒNICOPSIS Heer.

Phœnicopsis ? sp. Fontaine.

Pl. XXXIV, Figs. 13, 14.

Several fragments of strap-shaped leaves that at least suggest the presence of the genus Phœnicopsis were found in the Oregon Jurassic. They are quite rare, only two being found at locality No. 2, and one at locality No. 7. They are too poorly characterized to determine anything definite regarding them. They are strap-shaped fragments, which do not show either base or summit. They do not narrow at all from one end to the other. Their margins are strictly parallel. The widest of them are 8–10 mm. wide, and the smallest are but a little narrower. In at least one case several fragments occurring together converge at one end, as if to a common point. The leaf texture seems to have been thin. There are so far as seen no well-defined nerves, but a fine striation is shown on the surface. These fragments suggest Heer's species *Phœnicopsis speciosa.*[a]

[a] Fl. Foss. Arct., Vol. IV, Pt. II, pp. 112–113, pl. xxix, figs. 1 (excl. lc., ld.), 2; pl. xxx.

Pl. XXXIV, Fig. 13, shows three fragments which converge and overlap at one end. Fig. 14 is from a pen drawing, natural size, which shows the nervation more clearly.

Order PINALES.

Family TAXACEÆ.

Genus TAXITES Brongniart.

TAXITES ZAMIOIDES (Leckenby) Seward.

Pl. XXXIV, Figs. 15–17; Pl. XXXV, Figs. 1–3.

1864. *Cycadites zamioides* Leck.: Quart. Journ. Geol. Soc. London, Vol. XX, p. 77, pl. viii, fig. 1.

1875. *Taxites laxus* Phill.: Geology of Yorkshire, 3d ed., p. 231, lign. 64 on p. 231, pl. vii, fig. 24.

1900. *Taxites zamioides* (Leck.) Sew.: Manchester Memoirs, Vol. XLIV, Pt. III, No. 8, p. 5; Jur. Fl. Yorksh. Coast, p. 300, pl. x, fig. 5.

Leckenby described from the Oolite of Scarborough a small coniferous branch which he named *Cycadites zamioides*.[a] Seward calls this plant *Taxites zamioides*. As the leaves narrow to the base like those of Taxus, Seward is no doubt right in regarding the plant as a Taxites. There are at some of the Oregon localities numerous imprints of leaves exactly like those of this plant. In most cases they are detached, and sometimes they thickly cover the surface of the rock. In one case they were found attached, as in Taxus. The leaves are small but have a thick leather-like texture. They are about 4 cm. long and 1.5–2 mm. wide. They taper gradually to a subacute tip, and at base are abruptly rounded off and attached by a very short twisted petiole. The midnerve is very slender, but is sharply defined.

Pl. XXXIV, Figs. 15 and 16 (enlarged) give a portion of a twig with several attached leaves. Fig. 17 shows a number of detached leaves.

Pl. XXXV, Fig. 1 depicts several nearly entire leaves. Some of these are shown enlarged in Fig. 2. The specimen represented in Fig. 3 presents the appearance of a portion of rock covered with detached leaves.

The leaves are most common at locality No. 19 and are found also at localities Nos. 1, 7, 17, and 18.

[a] On the sandstones and shales of the Oolites of Scarborough, by John Leckenby: Quart. Journ. Geol. Soc. London, Vol. XX, p. 77, pl. viii, fig. 1.

Genus BRACHYPHYLLUM Brongniart.

Brachyphyllum mamillare Brongniart.

Pl. XXXV, Figs. 4–8.

1828. *Brachyphyllum mamillare* Brongn.: Prodrome, pp. 109, 200.[a]
1829. *Thuites expansus ?* Sternb. Phillips: Geology of Yorkshire, pp. 153, 167, 190, pl. x, fig. 11.[b]
1835. *Thuites expansus* Sternb. Lindley & Hutton: Foss. Fl. Gt. Brit., Vol. III, p. 49, pl. clxvii.
1836. *Brachyphyllum mammillare* Brongn. Lindley & Hutton: Op. cit., Vol. III, p. 99, pl. clxxxviii.
1837. *Brachyphyllum mammillare* Brongn. Lindley & Hutton: Op. cit., Vol. III, p. 177, pl. ccxix.
1870. *Brachyphyllum Phillipsii* Schimp.: Pal. Vég., Vol. II, p. 336.[c]

Several specimens of a plant that seems to be identical with *Brachyphyllum mamillare* Brongn. were obtained in the Oregon Jurassic. The plant is very rare and only small fragments of stems are usually found. These are poorly preserved and the leaves are generally distorted by pressure.

The specimen given in Pl. XXXV, Fig. 4 is a part of a branch about 12 mm. wide and 6 cm. long that has the leaves of this character. A small portion of it is shown enlarged in Fig. 5. Fig. 6 shows a small fragment of a branch with crowded leaves. This is shown enlarged in Fig. 7. Fig. 8 denotes a larger fragment that is of somewhat doubtful character. It is 9 cm. long and 2 cm. wide. It is an imprint made by a decorticated stem. It shows, irregularly placed and remote from one another, a number of obscure rhombic scars, and occasionally one that is elongate-elliptical, placed transverse to the axis of the stem. They can be seen distinctly only with the help of a lens. These scars

[a] Brongniart never described or figured this species, but it is on page 109 of the Prodrome that he describes the genus Brachyphyllum, and places in it only this one species. This has proved sufficient to enable others to identify it, and is equivalent to a description of the species. Brongniart, however, prepared drawings of the plant, which were afterwards completed and published by Saporta (Plantes Jurassiques, Vol. III, p. 328, pl. clxii [xxxiv], figs. 3–7).—L. F. W.

[b] The true *Thuites expansus* of Sternberg (Flora der Vorwelt, Vol. I, fasc. 3, p. 39, Tentamen, p. XXXVIII, pl. xxxviii, figs. 1, 2) from the Stonesfield slate does not seem to occur in the Yorkshire Oolite, but both Phillips and Lindley and Hutton wrongly referred some of the Yorkshire forms to that species.—L. F. W.

[c] Schimper considered the form figured by Lindley and Hutton in the Foss. Fl. Gt. Brit., Vol. III, pl. ccxix as a distinct species, and Saporta's fresh drawings of Brongniart's plant were regarded as establishing this fact. He states that both the figures of Lindley and Hutton are of the same specimen, but Mr. Seward, who found the specimen in the Manchester Museum, does not mention this, and the figures do not make it certain. Saporta says that Schimper was in error, and Mr. Seward includes this form in Brongniart species.—L. F. W.

appear to have been made by the bases of the leaves and are smaller than they would be if made by the surface of the boss-like leaves. The shape, too, would differ if made under these conditions.

This plant occurs at localities Nos. 2, 7, and 17.

Family PINACEÆ.

Genus ARAUCARITES Presl.

ARAUCARITES ? sp. Fontaine (cone scale).

Pl. XXXV, Fig. 9.

At locality No. 7 an apparent cone scale of Araucarites was found in a single specimen. It is quite convex, appearing hard and rigid, and was apparently quite thick. It is cuneate in form, expanding into a broad thick summit, the extreme tip being hidden. Toward the opposite end it narrows considerably, and at the end shows traces of former union with the axis of the cone. Its width at the summit is 18 mm. and its length 25 mm.

Genus PINUS Linnæus.

PINUS NORDENSKIÖLDI Heer.

Pl. XXXV, Figs. 10–17.

1876. *Pinus Nordenskiöldi* Heer: Fl. Foss. Arct., Vol. IV, Pt. I (Beitr. z. Foss. Fl. Spitzbergens), p. 45, pl. ix, figs. 1, 2, 2b, 3, 3b, 4, 5, 5b, 6.[a]

At several of the Oregon localities there are a number of long Pinus-like leaves that are always detached. They never appear in such numbers as the leaves of *Taxites zamioides*, but are more scattered. They agree well with the larger forms attributed by Heer to *Pinus Nordenskiöldi*. Some of them, however, are a good deal larger than any given by Heer. These larger forms can not be separated from certain smaller ones found in the Oregon flora, which agree very well in size with the largest of Heer. These leaves are pretty surely those of a Pinus and not of a Taxites. They narrow gradually to subacute tips and do not narrow to the base. In one case a fragment of the sheath may be seen attached to the base of a leaf, and two other leaves lie near this, as if they had once all belonged to the same bundle. There is a considerable variation in the size of the leaves. The largest leaves, none of which were seen entire, have a length of 115 mm.

[a] I do not include the *Cyclopitys Nordenskiöldi* (Heer) Schmalh. in the synonymy of this species, because after carefully comparing Schmalhausen's figures with those of Heer, I have grave doubt whether Schmalhausen had this plant at all. His genus Cyclopitys seems to be quite distinct.—L. F. W.

and a maximum width of 5 mm. The midnerve is strong and the texture of the leaves very thick and leather-like. They are often transversely wrinkled, no doubt from shrinkage.

Pl. XXXV, Fig. 10 represents a group of leaves, one of them showing traces of a sheath at its base. These are shown slightly enlarged in Fig. 11. Figs. 12 and 13 give portions of two medium-sized leaves. Figs. 14 and 15 represent the longest leaf seen, it not being entire. Figs. 16 and 17 denote the widest fragment found.

The leaves are most abundant at locality No. 19, and they are not rare at locality No. 7.

Genus CYCLOPITYS Schmalhausen.[a]

Cyclopitys oregonensis Fontaine n. sp.

Pl. XXXVI, Fig. 1, 2.

A single specimen, and its reverse, of a whorl of Taxus-like leaves was obtained at locality No. 7. Schmalhausen has established the genus Cyclopitys[b] for the plants that have an affinity with Sciadopitys. The Oregon fossil resembles those that he calls *Cyclopitys Nordenskiöldi*,[c] but the leaves are broader and not so rigid, and are probably longer. The Oregon fossil shows only one whorl, composed of 18 leaves, some of the leaves being evidently missing from the whorl. The leaves are attached by thin narrowed bases. The stem is not seen. The leaves are rather thin in texture. Their precise mode of attachment can not be made out, as their bases are crowded and distorted. They seem to be attached by narrowed bases and not by petioles. Only the basal portions of the leaves are preserved. They seem to have been of about the size of those of *Taxites zamioides*. There is a midnerve in each leaf that is rather slender. This nerve sometimes appears as a slender cord-like nerve with a depressed line on each side, and sometimes as two closely placed nerves. This difference seems due to the fact that in the one case the lower surface of the leaf made the imprint and in the other it was made by the upper face. Schmalhausen[d] regards Heer's *Pinus Nordenskiöldi* as a Cyclopitys. This may be the case with some of the forms that Heer has united in that

[a] It seems probable that this genus belongs to the family Taxaceæ instead of the family Pinaceæ.—L. F. W.

[b] Beiträge z. Jura-Fl. Russlands: Mém. Acad. Imp. Sci. de St. Petersb., 7e sér., Vol. XXVII, No. 4, pp. 39–41.

[c] 3 Op. cit., pl. xiv, figs. 6–8.

[d] Op. cit., p. 39.

species, for he seems to have been rather lavish in his application of the name, but it can hardly be assumed that the long Pinus-like leaves given by Heer from some localities are a Cyclopitys, or anything like it, for they are much longer than any of the forms that Schmalhausen gives of his *Cyclopitys Nordenskiöldi*.

Genus SPHENOLEPIDIUM Heer.

SPHENOLEPIDIUM OREGONENSE Fontaine n. sp.

Pl. XXXVI, Figs. 3–8.

A considerable number of specimens of a new species of Sphenolepidium were obtained from the Oregon localities. This is the fossil referred to as *Sphenolepidium Kurrianum* (Dunk.) Heer in a letter from myself to Professor Ward, quoted in Professor Ward's account of the Oregon Jurassic flora.[a] It was so referred from the examination of very imperfect specimens then in hand. The specimens obtained later are, it is true, all poorly preserved, but on some the leaves are well enough shown to give their true character, which indicates that the plant is a new species. The branches are slender and wide spreading. The leaves are small and have the form of an open sigmoid curve with incurved tips, the latter being quite obtuse. The curvature of the leaves resembles that of Pagiophyllum, to which genus I at first supposed the plant to belong. Unlike Pagiophyllum, the leaf is not wider at base than elsewhere. The leaves are rather slender and of delicate texture, so that they have suffered much in fossilization, the stems showing mostly only traces of them. They are closely appressed to the stem, about half the length of the leaf adhering to the stem and being decurrent on it. Only the upper portion is free. The midnerve could not be made out fully. Often, from maceration, the remnants of the leaves appear more acute than they really are. Occasionally a short branch may be seen bearing a cone. These cones have generally been too poorly preserved to show fully the character of the cone scales, but their arrangement gives fairly well the shape and size of the cone. The cones are about 8 mm. long and 5 mm. wide, and are oblong in form, resembling the cones of some of the Sphenolepidia of the Potomac formation. The scales are wedge-shaped and seem to have had shield-shaped ends.

[a] Twentieth Ann. Rep. U. S. Geol. Surv., Pt. II, 1900, pp. 369–370.

Pl. XXXVI, Fig. 3, shows a small twig on which some of the leaves are preserved entire. This is shown enlarged in Fig. 4. Fig. 5 shows one of the stoutest twigs found. Fig. 6 represents a branch of the largest size found, and it contains an attached cone. Fig. 7 gives an enlargement of the principal branch, and Fig. 8 one of the cones and twigs attached.

The plant is most abundant at locality No. 19, and is not rare at locality No. 18. It occurs also at localities Nos. 1 and 13.

Genus SAMAROPSIS Göppert.

SAMAROPSIS ? OREGONENSIS Fontaine n. sp.

Pl. XXXVI, Figs. 9–12.

Two small bony seeds were obtained from locality No. 7 that seem to be of the same nature as the small seeds described by Heer from the Jurassic of Siberia, and regarded by him as belonging to the fossil genus Samaropsis.[a] Although they are apparently nearer to these forms than to any other previously described plants, they do not seem to be identical with any of the species of Samaropsis described by Heer, and their true position is doubtful. The two Oregon fossils differ somewhat in form, but evidently are the seeds of the same genus if not the same species of plant. They seem to have been winged seeds. The wings show only traces in a marginal ring, the fossil being mainly the seed or nucleus to which the wing was attached. Owing to the difference in their form I shall distinguish them as form *a* and form *b*.

Both of these seeds have a smooth bony surface. They are surrounded by a depressed line representing the attachment of the wing to the seed. Outside of this there is a narrow border, less than 1 mm. wide, which is all of the wing that remains, if it ever existed.

Form *a*, represented in Pl. XXXVI, Fig. 9, enlarged in Fig. 10, is the larger of the two. It is oblong in form, abruptly rounded off at one end, which seems to be the base. The same width is maintained to near the opposite end, where it terminates in a lancet-shaped tip. This seed is 5 mm. long and a little over 2 mm. wide. Form *b*, given in Fig. 11, enlarged in Fig. 12, is cylindrical in shape, slightly narrowed at the ends, and

[a] Fl. Foss. Arct., Vol. IV, Pt. II, pp. 80–82.

rounded off there. It is slightly curved. It is 5 mm. long and not quite 2 mm. wide.

Whatever their true position may be, they are evidently very different from the other seeds found in the Oregon Jurassic.

MALE AMENT OF CONIFER.

Pl. XXXVI, Fig. 13.

From locality No. 7 there was obtained a single specimen of a catkin-like object that seems to be the male ament of some conifer. It is poorly preserved and shows only an axis about 3 cm. long, with the scales of one side only preserved. These are thickly crowded together and overlapping. They are thin in texture and ovate in form.

PLANTS OF DOUBTFUL AFFINITY.

Under this head I place a number of forms which are of more or less doubtful character.

Genus YUCCITES Schimper and Mougeot.[a]

YUCCITES HETTANGENSIS Saporta?

Pl. XXXVII, Figs. 1, 2.

1870. *Yuccites hettangensis* Sap. in Schimper: Pal. Vég., Vol. II, p. 427.
1886. *Yuccites hettangensis* Sap.: Plantes Jurassiques, Vol. IV, p. 74, pl. ccxxxv [ix]; pl. ccliii [xxvii].

Several ribbon-shaped imprints were found, mostly at localities Nos. 2 and 7. They seem to be made by broad grass-like leaves, but may be caused by thin succulent stems. They have parallel sides and do not diminish in width in the portions preserved. The largest fragment obtained is 125 mm. long, with neither base nor tip preserved. One side or margin is imperfect, and it may have been wider than it now appears. Still, the width of 25 mm. is shown. No definite nerves appear, but irregular and rarely strong nerves are seemingly shown,

[a] In view of the general doubt on the part of leading paleobotanists as to whether the forms described under this generic name are really related to the living genus Yucca or represent Monocotyledons at all, I have not thought best to introduce the Angiosperms as occurring in our Jurassic flora. Personally I do not believe that they occur, and it is probable, as Schenk suggests, that if we ever ascertain the true nature of these forms we shall find them to fall into that general line of development that seems to lead from the Cordaitales of the Paleozoic to the Ginkgoales.—L. F. W.

most of the surface being finely striate. The apparent strong nervation is probably a puckering from longitudinal folds in the leaf. The shape and size resemble these features in Saporta's *Yuccites hettangensis*.

Pl. XXXVII, Fig. 1, gives the largest and best specimen obtained. Fig. 2 represents a small area of it enlarged to show the nerves.

It occurs, as stated, at localities Nos. 2 and 7, but also at locality No. 19.

Undetermined leaf No. 1.

Pl. XXXVII, Figs. 3, 4.

A few detached leaf-like impressions are found at localities Nos. 2 and 7 that are too poorly preserved to be definitely determined. They are found as detached scraps. Fig. 3 shows three of them, placed as if once attached to a common support, and Fig. 4 is a pen drawing of one of these. They are strap-shaped in form and narrow slightly toward one end. The opposite ends of these fragments seem to be near their true bases, but the attachment is not visible. They seem to have been thick and succulent and to have had no definite nerves. There is an appearance of irregular nerves of unequal strength, but this is probably a puckering due to pressure. The general character of these objects is suggestive of the leaves, not bracts, of *Williamsonia gigas* (L. & H.) Carr., as given by Saporta.[a] Saporta maintains that this Williamsonia did not have the foliage of *Zamia gigas* (L. & H.), as Carruthers assumed.

Fig. 4 illustrates the best specimen found.

Undetermined leaf No. 2.

Pl. XXXVII, Figs. 5, 6.

One specimen of this leaf was found at locality No. 7. It is a long grass-like imprint, which has a vague fine striation and a seeming midrib. The latter is perhaps a longitudinal wrinkle. It has neither base nor tip, but is still 155 mm. long, with a width at one end of 15 mm. and at the other of 12 mm., indicating a narrowing. The seeming midrib shows no vascular tissue and is vaguely defined. Possibly this is a narrow Yuccites leaf. It is shown in Pl. XXXVII, Fig. 5, and a small area enlarged is shown in Fig. 6.

[a] Plantes Jurassiques, Vol. IV, pl. ccxlii [xvi], fig. 1.

Genus CARPOLITHUS Allioni.[a]

Carpolithus olallensis Ward n. sp.[b]

Pl. XXXVII, Figs. 7, 8.

Two nut-like objects were found at locality No. 7 that seem to be essentially the same, although varying slightly in form. They seem to be nut-like seeds, as they stand out quite convex from the stone

[a] In the Nineteenth Ann. Rep. U. S. Geol. Surv., Pt. II, 1899, p. 691, this generic name was credited to Artis, who used it in his Antediluvian Phytology, 1825, pp. XV and 22, in a systematic way. In the Twentieth Ann. Rep., Pt. II, 1900, p. 363, it was credited to Stokes and Webb, who used it one year earlier in a more obscure way, which I had overlooked. An explanatory footnote was appended in which I stated that this orthography was retained in preference to *Carpolithes* of Schlotheim, 1820, "on the assumption that it may ultimately be found to have priority when the investigation is complete," and I drew attention to the use of the plural form, *Carpolithi*, by Walch in 1771. Since that time I have made further investigations, and succeeded in verifying this surmise. In 1757 a work by Allioni (Carolus Allionius) was published in Paris with the following title: Oryctographiæ Pedemontanæ Specimen, exhibens corpora fossilia terræ adventitia. Pp. I–VIII+1–82+2 pp. index. On pages 3–14 the names Phytolithus, Lithoxylon, and Carpolithus occur, and are sufficiently described. Carpolithus occurs only once, on page 6, and under it a specimen is described in the following words:

"Fructum nucis Juglandis ochrâ quâdam terrificatum humanissime largitus est mihi amicissimus Richerius . . . Observatu dignum est, corticem, seu testam osseam fructûs nucis Juglandis consûmptam, integerrimo superstite fructu."

This fruit, as it seems from further explanations of the author, was sent to him by his friend Richerius, who found it on a well-known hill called la Morra, in Piedmont. Sismonda, who worked up the fossil flora of Piedmont (Prodrome d'une Flore tertiaire du Piémont, par Eugène Sismonda, Mém. Acad. Sci. de Turin, 2e sér., tome XVIII, pp. 519–547, pl. i–iv; Matériaux pour servir à la Paléontologie du Terrain Tertiaire du Piémont, par Eugène Sismonda, op. cit., 2e sér., tome XXII pp. 391–491, pl. i–xxxiii), gives Morra as the locality for the well-known fossil nut called *Juglans nuxtaurinensis*, named and described by Brongniart in 1822 (Mém. Mus. Hist. Nat. de Paris, Vol. VIII, p. 323, pl. xvii, fig. 6), which has been mentioned by many later authors, and of which Gaudin found additional specimens in the Val d'Arno. Brongniart speaks of it as a well-known nut at that time, popularly called "noix de Turin," but says it was found in the hills that form a part of the upper beds in the vicinity of Turin. He does not mention the work of Allioni, and none of the authors that have subsequently dealt with that form seem to have been acquainted with it. It seems probable that it is the same specimen which had lain in the Paris Museum ever since 1757. Brongniart's figure agrees very well with Allioni's description. Sismonda seems to have had other specimens from the same locality, as all agree that these nuts were common there, and that leaf impressions also occur in the same beds. Sismonda describes the geological relations at Morra and classes the beds in the Upper Miocene, but neither he nor any other author makes it clear just where la Morra is. There are several towns by that name in Italy, one of which is in Piedmont on the Tanaro, but it is doubtful whether this is the same. At all events the name Carpolithus is thus definitely established, and must now be credited to Allioni.

Prof. Ralph S. Tarr, who once did some literary work for the United States Geological Survey in the libraries of Cambridge and Boston, discovered this work of Allioni in the library of the Museum of Comparative Zoology at Harvard University and made some notes on a slip that he sent on with his papers. These notes were insufficient to decide the question, but the name Carpolithus occurred on the slip. In discussing the matter with Mr. David White, who has had the same difficulty with Carpolithus that I have had, he offered to write to Prof. J. B. Woodworth and ask him to investigate the question. Professor Woodworth very kindly did so and made a full report. It is from his letter that the above facts relative to Allioni's work are taken, and I take this opportunity to acknowledge my indebtedness to him.—L. F. W.

[b] The name given by Professor Fontaine to this form had already been twice used for other objects and had to be changed. The name I have chosen refers to Olalla Creek on a branch of which it was found.—L. F. W.

and show no trace of nervation. They are oblong elliptical in form, and at the tips are prolonged into an apparent beak. They are too large for seeds of cycads. The form given in Pl. XXXVII, Fig. 7, is 35 mm. long and 14 mm. wide in its widest portion. That shown in Fig. 8 is 3 cm. long and of the same width as that given in Fig. 7, but is more broadly elliptical. These objects look strikingly like the pyriform axis inclosed by the bracts of the involucre of what Saporta thinks is the male flower of *Williamsonia gigas*. They may be compared with the form given by Saporta in Plantes Jurassiques, Vol. IV, pl. xix, fig. 2. These pyriform objects seem often to have been detached from the involucres, and then would appear in the form shown by the Oregon fossils. Such an object may be inclosed by the infolded bracts of the fossil described in this paper as *Williamsonia oregonensis*. As there is no way of connecting them with Williamsonia, I describe them as Carpolithus.

CARPOLITHUS BUCKLANDII Williamson?

Pl. XXXVII, Fig. 9.

1836. *Carpolithes Bucklandii* Willn. in Lindley & Hutton: Foss. Fl. Gt. Brit., Vol. III, p. 103, pl. lxxxix, figs. 3, 5.

A large nut-like object was obtained from locality No. 7 that much resembles the *Carpolithes Bucklandii* Willn. figured by Lindley and Hutton. The base of the Oregon fossil is not shown, so it can not be compared with that of the English fossil. The latter, as given by Lindley and Hutton, shows on its surface a number of sharply defined prominences quite regularly formed. None such appear on the Oregon plant. Its surface is irregularly roughened, but the prominences are ill defined. In a few there are papillæ somewhat like those on the English fossil. The plant matter of the Oregon fossil is stripped off from the rock, and no doubt if the original surface had been preserved it would present a different aspect from that now shown. All that can be said is that the fossil has a suggestive resemblance to that of Lindley and Hutton.

The nut is quite large, being 4 cm. long and 22 mm. wide near the base. It is ovate in form and seems to narrow at the summit into a beak, but the end is not well preserved.

CARPOLITHUS OREGONENSIS Fontaine n. sp.

Pl. XXXVII, Figs. 10, 11.

Two large nut-like objects were found, one each at localities Nos. 1 and 7. They seem to be the same species. They are not unlike the seeds of *Ginkgo biloba*, but are much larger. They are broadly elliptical in form and are smooth on the surface and rounded at both ends, which do not differ in form. They are quite convex, but the original surface seems to have been removed.

The form given in Pl. XXXVII, Fig. 10, is 4 cm. long and 27 mm. wide in its widest part. That given in Fig. 11 is 37 mm. long and 27 mm. wide.

CARPOLITHUS ELONGATUS Fontaine n. sp.

Pl. XXXVII, Fig. 12.

A single specimen of a narrowly elliptical nut-like object was obtained at locality No. 7. It is the same type of plant as *Carpolithus oregonensis*, but is smaller and proportionally much narrower. The surface is smooth. It is slightly unsymmetrical, one longitudinal margin being more convex than the other. This may be due to distortion. Its full length is not preserved, but it is still 39 mm. long and 16 mm. wide. It was probably over 4 cm. in length, giving a great length in proportion to its width.

CARPOLITHUS DOUGLASENSIS Fontaine n. sp.

Pl. XXXVII, Fig. 13.

A single specimen of a peculiar pod-like organism was found at locality No. 19. It is not convex, but lies even with the surface of the rock and does not seem to have had much woody matter in its composition. It has at one end, the probable base, what looks like a fragment of the stem to which it was attached, and at the opposite end an apparent double beak, as if it were a two-valved pod. The length is 2 cm. and the width in the widest part 1 cm. It is elliptical in form, narrowing gradually from base to apex. Whatever it may be it is certainly different from any of the previously described nut-like objects. I name it from Douglas County, in which it was found.

CONCLUSIONS.

The following is the complete list of the plants found in the Oregon Jurassic:

1. Marchantites erectus (Bean) Sew.?
2. Dicksonia oregonensis Font. n. sp.
3. Coniopteris hymenophylloides (Brongn.) Sew.?
4. Thyrsopteris Murrayana (Brongn.) Heer.
5. Polypodium oregonense Font. n. sp.
6. Cladophlebis vaccensis Ward n. sp.
7. Cladophlebis denticulata (Brongn.) Nath. non Font.
8. Cladophlebis haiburnensis (L. & H.) Brongn.?
9. Cladophlebis acutiloba (Heer) Font. n. comb.
10. Cladophlebis pecopteroides Font. n. sp.
11. Scleropteris oregonensis Font. n. sp.
12. Ruffordia Gœpperti (Dunk.) Sew.
13. Adiantites Nympharum Heer?
14. Tæniopteris orovillensis Font.
15. Tæniopteris major L. & H.
16. Tæniopteris vittata Brongn.
17. Tæniopteris ? oregonensis Font. n. sp.
18. Macrotæniopteris californica Font.
19. Sagenopteris Gœppertiana Zign.
20. Sagenopteris paucifolia (Phill.) Ward n. comb.
21. Sagenopteris grandifolia Font. n. sp.
22. Danæopsis Storrsii Font. n. sp.
23. Equisetum sp. Font.
24. Ptilozamites Leckenbyi (Bean) Nath.
25. Nilsonia orientalis Heer.
26. Nilsonia orientalis minor Font. n. var.
27. Nilsonia parvula (Heer) Font. n. comb.
28. Nilsonia nipponensis Yok.
29. Nilsonia compta (Phill.) Göpp.
30. Nilsonia pterophylloides Nath. non Yok.
31. Pterophyllum Nathorsti Schenk.
32. Pterophyllum contiguum Schenk.
33. Pterophyllum æquale (Brongn.) Nath.
34. Pterophyllum rajmahalense Morr.
35. Pterophyllum minus Brongn.?
36. Ctenophyllum angustifolium Font.
37. Ctenophyllum pachynerve Font. n. sp.
38. Ctenophyllum Wardii Font.
39. Podozamites pulchellus Heer.
40. Podozamites pachyphyllus Font. n. sp.
41. Podozamites lanceolatus (L. & H.) Fr. Br. non Emm.
42. Podozamites lanceolatus minor (Schenk) Heer.
43. Podozamites lanceolatus latifolius (Fr. Br.) Heer.
44. Podozamites ? pachynervis Font. n. sp.
45. Ctenis sulcicaulis (Phill.) Ward n. comb.
46. Ctenis orovillensis Font.
47. Ctenis grandifolia Font.
48. Ctenis auriculata Font.?
49. Encephalartopsis ? oregonensis Font. n. sp.
50. Cycadeospermum oregonense Font. n. sp.
51. Cycadeospermum ovatum Font. n. sp.
52. Williamsonia oregonensis Font. n. sp.
53. Williamsonia ? sp. Font. Bract of Williamsonia ? No. 1.

54. Williamsonia ? sp. Font. Bracts of Williamsonia Nos. 2, a, b, c.
55. Ginkgo digitata (Brongn.) Heer.
56. Ginkgo Huttoni (Sternb.) Heer.
57. Ginkgo Huttoni magnifolia Font. n. var.
58. Ginkgo lepida Heer.
59. Ginkgo sibirica Heer.
60. Ginkgo sp. Font. Aberrant Ginkgos.
61. Phœnicopsis ? sp. Font.
62. Taxites zamioides (Leck.) Sew.
63. Brachyphyllum mamillare Brongn.
64. Araucarites ? sp. Font. (cone scale).
65. Pinus Nordenskiöldi Heer.
66. Cyclopitys oregonensis Font. n. sp.
67. Sphenolepidium oregonense Font. n. sp.
68. Samaropsis ? oregonensis Font. n. sp.
69. Male ament of conifer.
70. Yuccites hettangensis Sap.?
71. Undetermined leaf, No. 1.
72. Undetermined leaf, No. 2.
73. Carpolithus olallensis Ward n. sp.
74. Carpolithus Bucklandii Willn.?
75. Carpolithus oregonensis Font. n. sp.
76. Carpolithus elongatus Font. n. sp.
77. Carpolithus douglasensis Font. n. sp.

In determining from these plants the age of the strata that contain them, 40 must be eliminated as of no value. There are 22 new species, 2 new varieties, 7 species not positively determined, and 9 forms not specifically determined. It may be said of these that none are incompatible with the conclusion that the age of the strata is Jurassic. On the contrary, so far as they throw any light on the question of age, they indicate that it is Jurassic. The species that were doubtfully determined are the only ones that have any bearing on the question. They have at least some affinity with forms known from established geological horizons.

The plant doubtfully determined as *Adiantites Nympharum* has an affinity with Heer's species from the Lower Oolite of Siberia; *Pterophyllum minus* comes from the Lower Oolite of Yorkshire; *Ctenis auriculata* is found only in the Oroville strata, which are probably Lower Oolite in age; *Marchantites erectus* comes from the Lower Oolite of Yorkshire; *Yuccites hettangensis* is obtained from the Infralias of Hettange, a lower horizon than the Lower Oolite; *Carpolithus Bucklandii* comes from the Lower Oolite of Yorkshire. Thirty-seven species and varieties, over half of the entire number, are forms found in formations whose age is more or less fully established.

The following species have been found only in the Oroville strata of California: *Cladophlebis vaccensis, Tæniopteris orovillensis, Macrotæniopteris californica, Ctenophyllum angustifolium, Ctenophyllum Wardii, Ctenis orovillensis, Ctenis grandifolia.* There are thus 7 species found only in the Oregon and Oroville beds.

The following species and varieties have been found in the Oregon and Oroville strata and elsewhere in Jurassic beds: *Sagenopteris Gœppertiana, Pterophyllum rajmahalense, Podozamites lanceolatus, Podozamites lanceolatus latifolius, Pinus Nordenskiöldi,* 5 in all.

We find, then, that the Oroville and Oregon beds have in common 12 out of 37 fairly well-characterized species, nearly one-third. This shows pretty conclusively that whatever the age of these strata may be it is essentially the same. But these last-named 5 species are found in other localities besides the Oroville and Buck Mountain regions.

Sagenopteris Gœppertiana, according to Zigno, occurs in the Lower Oolite of Italy. *Pterophyllum rajmahalense* was first found in the Rajmahal series of India, which is held to be Liassic in age; but it does not differ apparently from Heer's *Pterophyllum Sensinovianum,* so, if Heer's conclusions as to the age of the strata containing it are correct, we may assume that it persists into the Lower Oolite. *Podozamites lanceolatus genuinus,* or *Podozamites lanceolatus* simply, is, like *Cladophlebis whitbiensis,* probably a much abused type of leaf. It probably is not a species, but rather a type of leaf found in many species which lived in Jurassic times. The original is from the Lower Oolite and the form is probably more characteristic of that period than any other of the Jurassic. The broad form, var. *latifolius,* seems to be more common in the Oolite than in any other epoch. *Pinus Nordenskiöldi* is apparently also especially characteristic of the Lower Oolite. This, too, is probably not a single species, but rather a type of Pinus leaf that was common in the Lower Oolite. It is quite probable that some of the forms placed in this species are really Taxites.

There remain 25 species that, as yet, have not been found at the Oroville locality. These, taken in connection with some of the last mentioned as common to Oregon and Oroville, show a remarkably large proportion of plants common to the Oregon beds and the two widely separated regions, Yorkshire in England and eastern Siberia. The element common to Oregon and eastern Siberia might be explained by supposing that in Jurassic times land connection existed between Asia and northwestern America. It is difficult to understand why so many forms should be common to England and northwestern America. In this connection it is interesting to note that several of the forms made

known by Richthofen from China exist in the Oregon flora. These will be noticed before taking up the plants common to Oregon, Yorkshire, and eastern Siberia. *Pterophyllum Nathorsti* and *P. contiguum* have, as yet, been found only in Oregon and in the Kwei-tshou beds of China. Schenk thinks that they can not be older than Lower Jurassic. As these strata, according to Schenk, contain *Podozamites lanceolatus* and *Nilsonia compta*, they are most likely Lower Oolite in age.

The Oregon strata have in common with the Kaga strata of Japan *Nilsonia nipponensis*. Yokoyama regards the Kaga strata as Lower Oolite.

The Oregon strata have in common with those of Yorkshire the following species, some of which are highly characteristic of the Yorkshire Lower Oolite:

1. Cladophlebis denticulata.
2. Cladophlebis haiburnensis.
3. Thyrsopteris Murrayana.
4. Ruffordia Göpperti.
5. Tæniopteris major.
6. Tæniopteris vittata.
7. Sagenopteris paucifolia.
8. Ptilozamites Leckenbyi.
9. Nilsonia compta.
10. Podozamites lanceolatus.
11. Ctenis sulcicaulis.
12. Ginkgo digitata.
13. Taxites zamioides.
14. Brachyphyllum mamillare.

Fourteen out of the 37 well-characterized species not new.

In common with the Siberian Jurassic there are the following:

1. Cladophlebis acutiloba.
2. Thyrsopteris Murrayana.
3. Nilsonia orientalis.
4. Nilsonia parvula.
5. Pterophyllum rajmahalense.
6. Podozamites pulchellus.
7. Podozamites lanceolatus.
8. Podozamites lanceolatus minor.
9. Podozamites lanceolatus latifolius.
10. Ginkgo digitata.
11. Ginkgo Huttoni.
12. Ginkgo lepida.
13. Ginkgo sibirica.
14. Seeds of Ginkgo.
15. Pinus Nordenskiöldi.
16. Brachyphyllum mamillare.

Sixteen out of the 37 determined species not new.

The Oregon strata rival those of eastern Siberia in the development of Ginkgos, and it is a noteworthy fact that nearly all the more important species made by Heer from those beds have similar forms in the Oregon strata. This similar great expansion of Ginkgos is strong proof

that the Oregon strata are of the same age as those of Siberia. We may go further and take it as good proof that the beds are not older than Lower Oolite. This large element of the Oregon flora common to both the Yorkshire and the Siberian strata may be taken as strong confirmation of Heer's belief in the identity of the age of the two formations.

There are in the Oregon flora, besides *Pterophyllum rajmahalence*, two previously known plants that point to a somewhat older age than Lower Oolite. They are *Pterophyllum æquale* and *Nilsonia pterophylloides*. Both of these are given by Nathorst as found in the Rhetic of Scandinavia. The latter has not hitherto been found in strata younger than the Rhetic. *Pterophlyllum æquale* has been noted by Schenk as found in the beds of the Tumulu coal field of China.[a] These strata are, he thinks, of Lower Oolite age.[b]

There can be no doubt, in the opinion of the present writer, that the Yorkshire Lower Oolites, the strata of eastern Siberia and of the Amoor, made known by Heer, and the Oregon beds are of the same age. The only question is, What is that age? The investigations of the English geologists would seem to have settled the question for the Yorkshire formation. Zeiller, in his paper discussing the age of the fossil flora of the Altai made known by Schmalhausen, in a footnote to page 478,[c] states that it is questionable whether the Siberian and Amoor plants described by Heer are really Lower Oolite in age. He thinks that the resemblance of this flora, in a number of its elements, to that of the Rhetic of Scandinavia makes the question an open one and that the age may be Lower Lias or even Rhetic. He takes pains, however, to state that he does not maintain that Heer's conclusions are erroneous, but that the question of age in the case of these strata merits further study. The key to the whole matter is the correctness of the determination of the age of the Yorkshire beds. So far as my knowledge goes no one has questioned the correctness of the conclusions of the English geologists regarding the age of the Yorkshire strata. That being established as Lower Oolite would certainly indicate a simi-

[a] Schenk, Jurassic Plants of China, pp. 247–248, pl xlviii, fig. 7.

[b] Op. cit., p. 265.

[c] Remarques sur la flore fossile de l'Altaï à propos des dernières découvertes paléobotaniques de MM. Bodenbender et Kurtz dans la République Argentine, par. M. R. Zeiller: Bull. Soc. Géol. de France, 3e sér., Vol. XXIV, Paris, 1896, pp. 466–487.

lar age for the Siberian beds and also for those of Oregon. The similarity of a number of the forms to those of the Lower Lias and the Rhetic may be explained by a survival of a portion of the Rhetic flora into the Lias and the Lower Oolite. It must be remembered that climatal conditions were apparently remarkably uniform throughout the Jurassic, a condition very favorable for the persistence of types. The resemblance between the plants of the Lower Lias and Rhetic formations and those of Yorkshire has long been known.

OTHER PLANT-BEARING BEDS IN THE JURASSIC, OR FORMING THE TRANSITION TO THE LOWER CRETACEOUS.

On August 8, 1884, Dr. A. C. Peale, while making investigations in northern Montana, collected a small specimen bearing the distinct impression of a coniferous leafy twig. It was found on the east slope of the Bridger Range, north of Bridger Creek, 4 miles northeast of Bozeman, in about latitude 44° 44′ N., longitude 110° 44′ W., in strata regarded by him as Jurassic, and the specimen was so labeled. It is in a limestone underlying the green sandstone described in Hayden's Annual Report for 1872, on page 475 ("Last foot of Bridger Peak, etc."). The plant proves to be the *Sequoia Reichenbachi*, which certainly extends to the base of the Cretaceous and has its ancestral forms in the Jurasic.

In the summer of 1884 Mr. Henry D. Woolfe sent to the Smithsonian Institution from Cape Lisburne, Alaska, two boxes of coal, some rock specimens, and some shales bearing leaf impressions. These last were referred to the Department of Fossil Plants of the National Museum, where they remained some time, but finally, on September 30, 1885, they were sent, along with a number of other undetermined collections, to Prof. Leo Lesquereux for determination. In due time Professor Lesquereux submitted his report, or rather a series of reports, which were compiled and edited by F. H. Knowlton and published in the Proceedings of the United States National Museum, Vol. X, pp. 21–46; Vol. XI, pp. 11–38, pl. iv–xvi. The plants from Cape Lisburne are described in Vol. X, p. 36, and Vol. XI, pp. 31–33, and figured mostly on pl. xvi of Vol. XI.

A larger and better collection than the one made by Mr. Woolfe and from the same general reigon has recently arrived. From the meager data that have been furnished it is learned that it was made

by Mr. H. D. Dumars 30 miles east of Cape Lisburne in 1890 and was donated to the National Museum by Mr. A. G. Maddren, of Seattle, Wash. It was taken from the Corwin coal mine. The rock is similar to that of the Woolfe collection and some of the species are the same, but there are others and very different ones. The specimens have a decidedly Lower Cretaceous, or even Jurassic, facies.

On December 15, 1900, Dr. T. W. Stanton turned over to me a specimen containing a well-marked impression, with its counterpart, of a leaf which was collected by Mr. A. C. Spencer in August of that year on Nikolai Creek near Nikolai, in the Copper River region of Alaska, in strata supposed to be Cretaceous or Jurassic.

In February, 1901, Doctor Stanton placed in my hands a small collection of fossil plants collected by Mr. Diller's party the previous season in Curry County, Oreg., at a locality in the Port Orford quadrangle, and labeled by Mr. Diller Jurassic or Lower Cretaceous.

In March of the same year Doctor Stanton referred to me a specimen collected by Mr. Ernest G. Locke, of Seattle, on Herendeen Bay, Alaska, labeled as coming from the "coal measures" of that region. The specimen showed the impression of a cycadaceous leaf.

Another collection from Alaska made in 1901 by Mr. F. C. Schrader was sent me by Doctor Stanton on November 25 of that year. The following is the list with field numbers attached. The trunk of a tree numbered A at the end of the list was not sent to Professor Fontaine. The label states that it was "collected by Mr. and Mrs. J. H. Rolland in 1901 in Iliamna oil region, Iliamna Bay, Cook Inlet, Alaska; apparently Mesozoic." It is probably coniferous, and has a warty exterior as if the bark was partially preserved.[a]

List of localities of fossil plants collected by F. C. Schrader during the season of 1901 along the one hundred and fifty-second meridian north of Arctic Circle and on the Arctic coast of Alaska.

(Horizon, probably Mesozoic.)

544. Fossil plant stems in dark, dirty gray sandstone or arkose. Locality, Anikovik River, cross ridge below camp 1.

545. Fossil plant stems in dark, dirty gray sandstone or arkose. Locality, Anikovik River, cross ridge below camp 1.

[a] After Professor Fontaine had sent in his report on this collection, I gave the names of the three species found in it to Mr. Schrader, and he published them in his paper entitled Geological section of the Rocky Mountains in northern Alaska: Bull. Geol. Soc. America, Vol. XIII, 1902, p. 245.

657. Fossil in slightly calcareous slate. Locality, Arctic coast, northeast of camp, September 12.

658. Fossil in slightly calcareous sandstone. Locality, Arctic coast, northeast of camp, September 12.

660. Fossil plants in dense, slightly calcareous sandstone. Locality, Arctic coast, northeast of camp, September 12.

661. Fossil plant stem in consolidated mud rock. Locality, Arctic coast, northeast of camp, September 12.

644. Fossil plants in sandstone. Locality, Cape Beaufort, Arctic coast.

672. Fossil plant stems in sandstone. Locality, Lisburne coal mines near Cape Lisburne, Arctic coast.

A. Trunk of tree or plant in impure, bluish-gray limestone from Iliamna Bay, Cook Inlet, as described on label.

During the field season of 1901 Mr. James Storrs, of Mr. Diller's party, collected some fossil plants in northern California. They were from three localities, one of which was on the divide between the Trinity and Sacramento rivers, near the head of Dog Creek; another was 3 miles above Whitney's, on the road to Trinity Center; the third was about 2 miles northwest of Slatonis on the old wagon road. The last two were in the Redding quadrangle, in Trinity County. The specimens from all these localities showed for the most part only faint traces of vegetable remains. Those from the first-named consisted of a matted mass of macerated leaves, apparently of some conifer, but wholly indeterminable. On a few slabs from the last-named locality, however, there occur a cone, much distorted by pressure, and some coniferous leaves and twigs, upon which Professor Fontaine has reported.

In this miscellaneous collection I shall also include the specimens from the Franciscan, or Golden Gate, deposits of Slate Springs, California, the history of which was given in the first paper,[a] which have since been determined and the single species named.

All of these specimens were sent to Professor Fontaine for determination, and he reports upon them as follows:[b]

[a] Twentieth Ann. Rep. U. S. Geol. Surv., Pt. II, 1900, pp. 338–339.

[b] For these small collections it will be sufficient to arrange the species in their systematic order without introducing the higher terms of the classification. Where they have already occurred in the larger report reference is made to the descriptions and synonymy.

REPORT ON THE VARIOUS COLLECTIONS DESCRIBED ABOVE.

By Wm. M. Fontaine.

1. PLANTS FROM CURRY COUNTY, OREG.

Mr. J. S. Diller collected 17 specimens of fossil plants from the Forks of Elk River, in the Port Orford quadrangle, Curry County, Oreg. The horizon is given as Jurassic or Lower Cretaceous. The plant material is very poorly preserved. Most of it is not determinable. All of it is in the form of small fragments, which have apparently been floated some distance from the place of growth. Hence the determination of all the fragments can not be positive. The following specimens are the only ones that possess character deserving notice.

Dicksonia oregonensis Fontaine?.[a]

Pl. XXXVIII, Figs. 1, 2.

One of the rock specimens from Curry County contains a small fragment of a fern that resembles *Dicksonia oregonensis* Font., of the Buck Mountain Jurassic beds. The specimen is a small fragment of the end of an ultimate pinna. This fragment contains several fructified pinnules. The sori are large and globose in form. They strongly suggest the identity of the plant with *D. oregonensis*. The latter and *Cladophlebis vaccensis* are not uncommon in the Jurassic strata occurring in the vicinity of Buck Mountain in Douglas County, Oreg., and have been described in this paper. Owing to the small amount of material from the Curry County beds the identification can not be positively made.

The specimen is shown natural size in Pl. XXXVIII, Fig. 1, and enlarged in Fig. 2.

Thyrsopteris Murrayana (Brongniart) Heer?[b]

Pl. XXXVIII, Figs. 3, 4.

On one of the specimens there occurs a small bit of a fern that resembles *Thyrsopteris Murrayana*. It is a part of the termination of an ultimate pinna, and carries several pretty well preserved pinnules. The form, texture, and nervation of these pinnules indicate strongly the presence of *T. Murrayana*. But this part of a fern frond is not well

[a] For the description of this species see pp. 55–56.—L. F. W.
[b] For the synonymy of this species see pp. 61–62.—L. F. W.

adapted for determination, and the amount of material is too small. This fern occurs quite commonly in the Buck Mountain Jurassic.

Pl. XXXVIII, Fig. 3, shows the specimen natural size, and Fig. 4 enlarged.

CLADOPHLEBIS VACCENSIS Ward.[a]

Pl. XXXVIII, Figs. 5, 6.

The fossil from Curry County, regarded as probably a specimen of *Cladophlebis vaccensis*, consists of a single detached pinnule. It agrees exactly with some of the pinnules of that fern. Of course a positive identification can not be made with so small an amount of material.

Pl. XXXVIII, Fig. 5, shows the specimen natural size, and Fig. 6 enlarged.

CTENIS SULCICAULIS (Phillips) Ward?[b]

Pl. XXXVIII, Figs. 7, 8.

Two fragments of leaflets are found in the Curry County fossils that seem to belong to *Ctenis sulcicaulis*. They are detached and show neither base nor tips, so that the true position of the fragments can not be determined. *C. sulcicaulis* is an important fossil in the Buck Mountain Jurassic strata. In these small fragments the texture and the slender nerves agree well with those features in the Buck Mountain fossil. The mode of anastomosis of the nerves in both is exactly the same.

Pl. XXXVIII, Fig. 7, gives the most complete fragment. The nerves are so fine that they can be made out only with the help of a lens. They are shown enlarged in Fig. 8.

CTENOPHYLLUM ? sp. Fontaine n. sp.?

Pl. XXXVIII, Figs. 9, 10.

On the rock specimens of the collection there are several strap-shaped fragments of leaves that indicate the presence of a Ctenophyllum of the type of *C. densifolium*[c] of the Oroville flora. If it is a Ctenophyllum it is probably a new species, but the material is too imperfect and too small in amount to permit a full and accurate diagnosis to be given. The

[a] For the description of this species see pp. 66–68.—L. F. W.
[b] For the synonymy of this species see p. 113.—L. F. W.
[c] Twentieth Ann. Rep. U. S. Geol. Surv., Pt. II, 1900, pp. 358–359, pl. lxi.

leaflets occur only in small fragments, which are not attached and show no terminations.

Pl. XXXVIII, Fig. 9, gives the most complete specimen. This shows three fragments with the tips and bases not preserved. They are so placed as to indicate that they were once attached to a common stem. They are, on an average, 5 mm. wide. The nerves are the most characteristic feature. They are exceedingly fine and close, being visible only with the help of a lens. At least five occur in the space of 1 mm., and sometimes they are even closer. They are single and parallel. Fig. 10 shows one of these leaflets enlarged.

PODOZAMITES LANCEOLATUS MINOR (Schenk) Heer.?[a]

Pl. XXXVIII, Figs. 11, 12.

The Curry County beds have yielded several small fragments of detached leaves that seem to be *Podozamites lanceolatus minor* Heer. The exact character can not be made out, as the leaves are not attached and their bases and ends are not preserved. The fragments agree well with the small form of *P. lanceolatus*, regarded by Heer as a distinct variety and called by him var. *minor*. The nervation is fine, close, and approximately parallel. This is another of the plants that are probably common in the Curry County and Buck Mountain floras, for *P. lanceolatus minor* is found in the Buck Mountain localities. The material from Curry County is not sufficient to permit a positive identification.

Pl. XXXVIII, Fig. 11, shows the most complete leaflet natural size, and Fig. 12 the same enlarged.

OTOZAMITES OREGONENSIS Fontaine n. sp.

Pl. XXXVIII, Figs. 13, 14.

Two fragments occur in this collection, one on each of two rock specimens, that seem to be a new species of Otozamites. The fragments do not suffice for a complete diagnosis, but perhaps justify a description of the plant as a new species.

The most complete and largest specimen is depicted in Pl. XXXVIII, Fig. 13, and a smaller and less complete one is given in Fig. 14. The

[a] For synonymy see p. 111.—L. F. W.

larger leaf is torn in half longitudinally, and the smaller one shows the basal part nearly complete. The larger leaf gives the shape best, and hence this will be taken for description. It is 35 mm. long, oblong in form, and tends to assume a flabellate shape. It narrows slightly toward the base and was attached by the middle point of the base, which was slightly auriculate. It is widest near the end, which is rounded off very obtusely. It was probably 25 mm. wide near the end. The nerves are very fine and closely placed. They diverge from the insertion of the base and fork repeatedly, so as to fill the lamina of the leaf. In form and size the leaves resemble those of *Otozamites Klipsteini superba* Sew., from the Wealden of England. They most resemble those of the form figured on pl. vii, fig. 9, of Seward's Wealden Flora, Pt. II, but the leaves now in question narrow more toward the base.

TAXITES ZAMIOIDES (Leckenby) Seward.[a]

Pl. XXXVIII, Figs. 15–18.

The principal specimen regarded as representing *Taxites zamioides* is a small bit of a twig with the bases of several leaves attached to it. Enough of the leaf is preserved to show a very close agreement with the *T. zamioides* of the Lower Oolite of Yorkshire, England. On some of the specimens several detached leaves occur that are nearly entire, and which agree well with those of this conifer. This conifer occurs at some of the Jurassic localities in the vicinity of Buck Mountain, Oregon, not rarely, and has been described by the writer in this paper. This is shown natural size in Pl. XXXVIII, Fig. 15, and enlarged in Fig. 16. A single nearly complete leaf found detached is represented in Fig. 17, and Fig. 18 shows this enlarged.

The above-described plants are all that can be made out with any degree of certainty in the collection from Curry County. They indicate with a high degree of probability that the strata which yield them are of the same age as the Jurassic strata of Douglas County in the vicinity of Buck Mountain. The abundant plant fossils of these beds show that they are of Lower Oolite age.

[a] For the synonymy of this species see p. 129.

2. PLANTS FROM HERENDEEN BAY, ALASKA.

PTEROPHYLLUM ALASKENSE Fontaine n. sp.

Pl. XXXVIII, Figs. 19, 20.

This is a fragment of a cycad leaf which is most probably a Pterophyllum. It belongs to that type of Pterophyllum of which *P. rajmahalense* Morris is the most important example. This, however, seems to be a new species. The leaflets are remote and attached to the side of the axis or midrib by the whole of a somewhat widened base. This is the most important difference distinguishing this plant from *P. rajmahalense*. The leaflets are oblong in form, with very obtuse ends. As is common in Pterophylla of this type, they show some variation in width even in the same compound leaf. The length for the average size is about 14 mm. and the width above the base 4 mm. The nerves are not well shown, but seem to be slender and numerous, parallel, and about 12 in number. They may be more numerous in the wider leaflets. The texture of the leaflets is rather thin. Owing to the expansion of the bases of the leaflets they touch one another in those parts and are even united there with a U-shaped sinus. The largest leaflets may be twice as wide as the narrowest. As in the case of *P. rajmahalense*, the variation in size is mainly in the width, the length remaining pretty constant.

The specimen is shown natural size in Pl. XXXVIII, Fig. 19, and a portion of it enlarged in Fig. 20.

Only a single specimen of this plant was found. It was collected by Mr. Ernest S. Locke from the "coal measures" of Herendeen Bay, Alaska. Doctor Stanton states that the invertebrates accompanying this plant are *Aucella crassicollis*, a Lower Cretaceous species.

3. PLANTS FROM THE COPPER RIVER REGION, ALASKA.

SAGENOPTERIS ALASKENSIS Fontaine n. sp.

Pl. XXXVIII, Fig. 21.

This plant is found in only one specimen, which is a nearly complete leaf, apparently a lateral one of the cluster characteristic of Sagenopteris. It was collected by Mr. A. C. Spencer from the Copper River region of Alaska, on Nikolai Creek near Nikolai. It is apparently one of the lateral

leaves of the group, as it is unsymmetrical in shape. The leaf is broadly elliptical in form, narrowing to an obtuse tip. The basal part of the leaf, on the left-hand side, is not entire, but the margin on this side was evidently not so strongly curved as the right-hand margin. The leaf texture was evidently thick and leathery, for the leaflet leaves a very distinct impression, although it is preserved in a coarse grit. The most complete leaflet has a length of 7 cm. It is widest near the base, where it is 4 cm. wide. The midnerve is flat and obscure and it does not exist for more than one-third of the length of the leaf. The secondary nervation can not be made out.

This plant is quite near *Sagenopteris Göppertiana* from the Lower Oolite of Italy,[a] which is common also in the Jurassic formation of the Buck Mountain region of Oregon. It is clearly a Sagenopteris of the same type, but is apparently a new species. The leaf is broader in proportion to its length than any of Zigno's forms and belongs to a larger plant. The mid nerve also is not so distinct as it is in Zigno's leaves. Stanton states that the shells associated with this plant indicate an Upper Jurassic or Lower Cretaceous age. Its resemblance to *S. Göppertiana* points to a Jurassic age, but a single fossil like this can not be decisive.

4. PLANTS FROM THE VICINITY OF CAPE LISBURNE, ALASKA.

A good many years ago Mr. Henry D. Woolfe collected a few fossil plants said to be from Cape Lisburne, Alaska (see p. 145). They found their way to the National Museum and were sent to Lesquereux for determination. He described them and figured a number of them in the Proceedings of the National Museum, published in 1887 (Vol. X, p. 36) and 1888 (Vol. XI, pp. 31–33, pl. x, fig. 4; pl. xvi). He identified some of them with Lower Oolitic plants, but most of them with Cenomanian fossils from the Atane beds of Greenland. He regarded them as of Neocomian age.

In 1890 Mr. H. D. Dumars made a small collection of fossil plants from the Corwin coal mine, 30 miles east of Cape Lisburne. These also were presented to the National Museum (see p. 146). It is not known whether or not the localities from which these two collections were

[a] Zigno, Foss. Fl. Form. Oolith., Vol. I, pp. 188–190, pl. xxi, figs. 1–5; pl. xxii, figs. 1, 2.

made are the same. The rock of some of the specimens in both collections is exactly alike, and many of the plants are the same. There can be no doubt that both of these collections show plants belonging to the same flora.

In 1901 Mr. F. C. Schrader collected a few fossil plants on the northwest coast of Alaska, about 180 miles northeast of Cape Lisburne (see p. 146). The locality is between Icy Cape and Wainwright Inlet. A number of the rock specimens show only indeterminable fragments of plants. Four fragments of rock, however, give fossils exhibiting enough character to be determined with some certainty. These fossils belong to the same flora as that shown in the Woolfe and Dumars collections, and, with one exception, are probably all identical with forms found in these two collections. The rock material also which bears Schrader's plants is strikingly like that containing the fossils of the other two collections. Although the amount of material obtained by Mr. Schrader, available for comparison, is small, it is sufficient to indicate strongly that it comes from a formation of the same age as that yielding the two collections previously made.

All of these collections have been turned over to me for examination and the present paper gives the results.

DESCRIPTIONS OF THE SPECIES.

Phylum THALLOPHYTA.

Order RHODYMENIALES.

Family RHODOMELACEÆ.

Genus CHONDRITES Sternberg.

CHONDRITES FILICIFORMIS Lesquereux.

1888. *Chondrites filiciformis* Lx.: Proc. U. S. Nat. Mus., Vol. XI, p. 32, pl. xvi, fig. 1.[a]

[a] Professor Fontaine considers this specimen too vague for determination. It is, however, quite clear on the stone and Lesquereux's figure represents it fairly well. It may stand as a problematical organism.—L. F. W.

Phylum PTERIDOPHYTA (Ferns and Fern Allies).

Order FILICALES (Ferns).

Family CYATHEACEÆ.

Genus DICKSONIA L'Héritier.

Dicksonia Saportana Heer.

Pl. XXXIX, Figs. 1, 2.

1876. *Dicksonia Saportana* Heer: Fl. Foss. Arct., Vol. IV, Pt. II (Jura-Fl. Ostsibiriens und d. Amurlandes), p. 89, pl. xvii, figs. 1, 1c, 2, 2b; pl. xviii, figs. 1, 1b, 2, 3.

1888. *Asplenium Dicksonianum* Heer. Lesquereux: Proc. U. S. Nat. Mus., Vol. XI, p. 32, Cat. U. S. Nat. Mus., No. 2435.

On a small fragment of rock collected by Mr. Woolfe there is an imprint of a fern that agrees well with *Dicksonia Saportana* as determined by Heer from the Jurassic of Siberia. Indeed, in form and size of the pinnules and in the rather uncommon nervation this fossil is exactly like fig. 2 of pl. xvii of Heer's work. The specimen shows a portion of a penultimate pinna with a number of ultimate ones, in which the terminations are wanting. Most of the pinnules are more or less lacerated, and this probably caused Lesquereux to make an erroneous determination of the plant. He regarded it as *Asplenium dicksonianum* Heer. The entire pinnules, however, have no resemblance to this plant. Only one specimen was found.

Pl. XXXIX, Fig. 1, gives the fragment, and Fig. 2 a pinnule magnified.

Family POLYPODIACEÆ.

Genus ONYCHIOPSIS Yokoyama.

Onychiopsis psilotoides (Stokes & Webb) Ward n. comb.

Pl. XXXIX, Figs. 3–6.

1824. *Hymenopteris psilotoides* Stokes & Webb: Trans. Geol. Soc. London, 2d ser., Vol. I, p. 424, pl. xlvi, fig. 7; pl. xlvii, fig. 2.

1827. *Sphenopteris Mantelli* Brongniart in Mantell: Illustrations of the Geology of Sussex [revised edition], p. 55.

1836. *Cheilanthites Mantellii* (Brongn.) Göpp.: Syst. Fil. Foss., p. 231.

1839. *Cheilanthites denticulatus* F. A. Roemer [non (Brongn.) Göpp.]: Verst. d. Norddeutsch. Oolithen-Gebirges, Nachtrag, p. 9, pl. xvii, fig. 1a.
1843. *Confervites fissus* Dunk.: Program d. höheren Gewerbschule in Cassel, 1843–1844, p. 5.
1846. *Confervites fissus* Dunk.: Monogr. d. Norddeutsch. Wealdenbildung, p. 1, pl. i, fig. 1.
1846. *Sphenopteris Römeri* Dunk.: Op. cit., p. 3, pl. i, figs. 3, 4, 4a, 5.
1846. *Sphenopteris tenera* Dunk.: Op. cit., p. 3, pl. viii, fig. 5.
1865. *Microlepia Mantelli* (Brongn.) Ett.: Farnkräuter der Jetztwelt, p. 216.
1867. *Sphenopteris antipodum* Tate: Quart. Journ. Geol. Soc. London, Vol. XXIII, p. 146, pl. vi, fig. 3.
1888. *Aspidium Oerstedi* Heer. Lesquereux: Proc. U. S. Nat. Mus., Vol. XI, p. 32 in part, quoad Cat. U. S. Nat. Mus., No. 2434, Lesquereux's Nos. 913–915.[a]
1894. *Onychiopsis Mantelli* (Brongn.) Sew.: Wealden Flora, Pt. I, p. 41, figs. 4, 5 on p. 50, fig. 6 on p. 52, pl. ii, fig. 1; pl. iii, figs. 1–4.

Four specimens of a fern with very slender incisions are found in the collections of Woolfe and Dumars. Three of them are in Mr. Woolfe's collection. These were identified by Professor Lesquereux with *Aspidium Oerstedi* Heer. Lesquereux must have given this collection a very hasty examination, for this plant has not the slightest resemblance to *A. Oerstedi*. The three specimens collected by Mr. Woolfe appear to belong to the upper part of the compound pinna or frond. One of them is given in Pl. XXXIX, Fig. 5. Fig. 6 represents a magnified ultimate pinna of the same in which the pinnules are reduced to lobes. The fossil collected by Mr. Dumars apparently belongs to a lower portion than these. This is given in Pl. XXXIX, Fig. 3, and Fig. 4 represents, magnified, a portion in which the lobes have become pinnules. This form is a fragment of a compound pinna, or of the frond, which toward its termination passes into the form given in Fig. 5. These specimens show that the plant has the following character:

The ultimate pinnæ make an acute angle with the penultimate rachis, which is apparently winged by a decurrence of the lowest pinnules. They are narrowly oblong and have linear, almost threadlike, acute pinnules, which are set on very obliquely and united at base, so as to make the rachis of the ultimate pinna winged. They diminish in size

[a] Unfortunately all the specimens referred by Professor Lesquereux to the same species were given the same number in the catalogue of the United States National Museum, and as Professor Fontaine refers the specimens to different species there would be no way of indicating his determinations had not Lesquereux attached to each imprint a private number of his own. I am therefore obliged to quote his private numbers in addition to the Museum number.—L. F. W.

toward the ends of the ultimate pinnæ and are more and more united, so that they pass to lobes and finally to teeth. The obliquity of insertion of the pinnules makes the bases of the ultimate pinnæ wedge shaped. Toward the termination of the compound pinna, or frond, the ultimate pinnæ become reduced to pinnules. In such parts the penultimate pinnæ, now reduced to ultimate ones, are much elongated and toward their ends have the pinnules passing into lobes and finally into teeth. Toward the ends of the compound pinna the ultimate pinnæ become reduced to elongate dentate pinnules. The same obliquity, narrowness, and acuteness are maintained in these transformations into lobes and teeth. The nervation can not be made out, as all the specimens are preserved in a sandstone. No fructification is shown, and the plant must be determined from the character of its sterile parts. It differs somewhat from the character of *Onychiopsis psilotoides* as given in most of the specimens hitherto described, but the variation does not appear greater than the limits of the species. The variation is found in the facts that the Alaskan fossil has the pinnules, lobes, and teeth more closely placed than in most of the forms of *O. psilotoides* and that the laminæ of the foliage is in greater proportion to the nervation. The crowding may be due to a creep of the rock and to pressure, for these features appear in the specimens.

This plant resembles *O. elongata* (Geyl.) Yok., a Jurassic fossil, but is more delicately incised. It probably lies between it and *O. psilotoides*. It is also near a number of fossils described in Monogr. U. S. Geol. Surv., Vol. XV (The Potomac or Younger Mesozoic flora). It especially resembles *Thyrsopteris angustifolia* Font., the form given in Fig. 8 being much like those depicted in that work on pl. xlv, fig. 3, and pl. xlviii, fig. 2. But the pinnules and lobes of the Alaskan plant are more slender than even these.

Genus CLADOPHLEBIS Brongniart.

CLADOPHLEBIS VACCENSIS Ward.[a]

Pl. XXXIX, Figs. 7, 8.

1888. ?*Pecopteris denticulata* Heer. Lesquereux: Proc. U. S. Nat. Mus., Vol. XI, p. 32.

On one of the rock fragments collected by Mr. Woolfe there is an imprint of fern which has the Museum No. 2526 and Professor Lesque-

[a] See pp. 66–68.

reux's No. 909b. This is given by Lesquereux as *Pecopteris denticulata* Heer. He gives no description and no figure of it. The imprint shows several imperfect ultimate pinnæ carrying a number of mostly mutilated pinnules. The pinnæ are detached, but so placed as to show that they were once attached to a common rachis. Enough, however, of the character of this plant is shown to make it most probable that it is identical with *Cladophlebis vaccensis*, found in the Jurassic (Lower Oolite) flora of Douglas County, Oreg., and described on page 66. Only one specimen of this fossil occurs in the collections. It is represented in Pl. XXXIX, Fig. 7, and one of the pinnules with its attachment to the rachis is shown in Fig. 8.

CLADOPHLEBIS ALATA Fontaine.

Pl. XXXIX, Figs. 9–11; Pl. XL.

1888. *Aspidium Oerstedi* Heer. Lesquereux: Proc. U. S. Nat. Mus., Vol. XI, p. 32 in part, quoad Cat. U. S. Nat. Mus. No. 2434, Lesquereux's Nos. 910b, 910c, 911b, 912, 916, 917.

1888.? *Pinus staratschini* Heer. Lesquereux: Proc. U. S. Nat. Mus., Vol. XI, p. 32.

1889. *Cladophlebis alata* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 77, pl. xix, figs. 5, 5a.

1889. *Pecopteris strictinervis* Font.: Op. cit., p. 84, pl. xiii, figs. 6, 6a, 7, 7a, 8, 8a; pl. xix, figs. 9, 9a; pl. xx, figs. 3, 3a; pl. xxii, figs. 13, 13a; pl. clxx, figs. 5, 5a, 6, 6a.

The most common, and perhaps the most characteristic fern of the two collections, is one of those that Lesquereux identified with *Aspidium Oerstedi* Heer, although it is entirely different from that plant and the others of Woolfe's collection that he placed in that species. Some of the larger rock fragments contain a number of imprints. The amount of material enables one to get a pretty good idea of the character of the fossil. The specimens seem all to belong to parts pretty high up on the pinnæ. The most complete specimens show a considerable portion of an antepenultimate pinna, which carries portions of several penultimate and ultimate pinnæ containing a number of pinnules. Whether or not this represents the frond or only a compound pinna can not be determined. It is probably only a pinna. It shows that the frond must have been of considerable dimensions and that the plant was probably arborescent. The rachises are strong and rigid. The primary and secondary rachises of this specimen, given in Pl. XL, Fig. 1, seem

to have been a raised cord-like line, running down the center of their upper surface. The primary pinnæ of this specimen go off from the main rachis opposite to one another. Pl. XL, Fig. 2, shows two of the pinnules enlarged. Another specimen, which is given in Pl. XL, Fig. 3, seems to belong to a position nearer the end of the compound pinna than the part represented in Fig. 1. It is also a portion of an antepenultimate pinna. In this the ultimate pinnæ are much reduced in size, and the same is true of the pinnules. The latter are more united and tend to pass to lobes and teeth. Many of the pinnules and lobes in this form are much mutilated and do not show their true shape. Pl. XL, Fig. 4, shows the lower part of a pinnule enlarged. The form given in Pl. XL, Fig. 5, probably represents a stage between these two. This gives one of the penultimate pinnæ more complete. Pl. XL, Fig. 6, shows a pinnule enlarged. Pl. XXXIX, Fig. 9, probably represents a portion of a penultimate pinna from lower down on the compound pinna than any of those shown in Pl. XL, Fig. 1. In this the pinnules are more separated than in any of the other specimens. They are also larger, and the largest of them show serrate teeth. These can be seen distinctly only with the help of a lens. They are shown in the magnified pinnule, Pl. XXXIX, Figs. 10 and 11. It is probable that still lower down the teeth become more pronounced and take the character shown in *Cladophlebis alata*.

This plant seems to be identical with two ferns first found in the Potomac, or Lower Cretaceous formation. They are *Cladophlebis alata* and *Pecopteris strictinervis*. These specimens make it most probable that the two ferns from the lower Potomac of Virginia, called by the present writer *Cladophlebis alata* and *Pecopteris strictinervis*, are the same. *Pecopteris strictinervis* represents upper and terminal portions of the frond and compound pinnæ. *Cladophlebis alata* is the form found lower down. The larger pinnules of the fossil represented in Pl. XXXIX, Fig. 9, are forms establishing a passage from the *alata* to the *strictinervis* type. Most of the specimens belong to the *strictinervis* type, and none with dentation so pronounced as that in *C. alata* were found. Some of the pinnules of *Pecopteris strictinervis*, as seen in the Virginia Potomac, show a toothing similar to that found in the form depicted in Fig. 3. The following description of the fossil may be given:

The plant was probably arborescent with strong rachises and wide spread of foliage. The epidermis seems to have been firm and durable,

so that the plant matter of the pinnules is usually well preserved and leaves a shining film on the stone. The rachis of the ultimate pinna is winged by the decurrence of a pinnule, or lobe, placed in the angle between the lower side of the base of the ultimate rachis and the penultimate one. The larger pinnules in Pl. XXXIX, Fig. 9, the dentate ones, may be regarded as normal for the frond. As stated above, they diminish in ascending on the frond, and also toward the ends of the ultimate pinnæ, becoming entire and more united, until they pass into lobes and finally into teeth. The general character of the normal pinnules is maintained until they are reduced to lobes and teeth, when they become proportionally broader at base, taking more or less of an ovate form.

The normal pinnules are narrowly oblong and acute. They are decurrent at base and united with the next lower ones, forming a narrow wing on the ultimate rachis. On the upper side of the base they are slightly constricted, the constriction being more pronounced the deeper the toothing. The larger and lower pinnules have minute teeth that are acute and inclined strongly toward the tips of the pinnules. They often have a spiny look and can not be seen distinctly without the help of a lens. The pinnules are generally straight, but may be slightly falcate. They go off obliquely from the ultimate rachis and are inclined forward toward its end.

The midnerve of the pinnules is rather slender and continues to near the end of the pinnules. The lateral nerves go off pinnately and very obliquely. They are straight. In the toothed pinnules the lower ones are once forked, the rest are single. In the entire pinnules and lobes they are single. This plant has a good deal of resemblance to *Aspidium montanense* Font.[a] of the Kootanie strata of Great Falls, Mont. But the Montana plant has the pinnules, lobes, and teeth more obtuse and not so strongly inclined forward. Pl. XL, Fig. 7 probably represents a portion of a penultimate pinna from the upper part of the compound pinna, where the ultimate pinnæ carry pinnules reduced to lobes. It shows the slender elongate form of these. Figs. 8 and 9 show enlarged pinnules of this.

The fossil Lesquereux determines as *Pinus! Staratschini* does not seem to be Pinus. It looks like the rachis of *Cladophlebis alata.*

[a] Description of some fossil plants from the Great Falls coal field of Montana: Proc. U. S. Nat. Mus., Vol. XV, p. 490, pl. lxxxii; pl. lxxxiii, figs. 1, 1a, 2, 3, 3a.

CLADOPHLEBIS HUTTONI (Dunker) Fontaine n. comb.

Pl. XLI–XLIII.

1846. *Neuropteris Huttoni* Dunk.: Monogr. d. Norddeutsch. Wealdenbildung., p. 9, pl. viii, fig. 1.
1849. *Pecopteris Huttoni* (Dunk.) Brongn.: Tableau, p. 107.
1869. *Alethopteris Huttoni* (Dunk.) Schimp.: Pal. Vég., Vol. I, p. 570 [by typ. error A. Murchisoni].
1874. *Alethopteris Huttoni* (Dunk.) Schimp.: Op. cit., Atlas, p. 14, pl. xxxi, fig. 10.
1888. *Aspidium Oerstedi* Heer. Lesquereux: Proc. U. S. Nat. Mus., Vol. XI, p. 32 in part, quoad Cat. U. S. Nat. Mus., No. 2434, Lesquereux's Nos. 918, 920, 926, 927.
1888. *Asplenium Fœrsteri* Deb. & Ett. Lesquereux: Loc. cit.

Five specimens of a large fern were collected by Mr. Woolfe. They are rather poorly preserved and do not show the full character of the plant. Four of these determined by Lesquereux as *Aspidium Oerstedi* Heer and one as *Asplenium Fœrsteri* Deb. & Ett. The narrower pinnules, occurring on one of the imprints, are not unlike some of those of *Aspidium Oerstedi*. The collection of Mr. Dumars contains several large slabs of rock, which show a number of imprints of this form better preserved and more complete than those of Mr. Woolfe. They are also mostly from different parts of the plant. These show that the plant is a fern that can not well be distinguished from the fossil that Dunker described from the Wealden of Hanover, with the name *Neuropteris Huttoni*. This seems to have been the only specimen ever found. As it is only a small fragment it can not show the full character of the plant. Schenk examined this specimen and approved of Schimper's name for it, *Alethopteris Huttoni*.[a] He gives a figure of it differing somewhat from that of Dunker, and probably a more nearly correct one. Dunker figures the plant as having two complete pinnæ attached to a large rachis, portions of which show the original width. Schenk's figure shows the principal rachis with all of the margin on one side wanting, so that the true width is not seen. The only attached pinna is the upper one, and the end of that is wanting. The next lower pinna has the end preserved, but its full length is probably not given, as the base is defective and the pinna visible is only a portion

[a] Foss. Flor. der Nordwestdeutsch. Wealdenformation (Palaeontographica, Vol. XIX, 1871), p. 217 [15], pl. xxix [viii], figs. 1, 1a.

of the original one. The specimens in the collections from Alaska show that pinnæ in the position on the frond shown in Dunker's specimen are longer then these, although they are remarkably short for foliage of such size. This fern has an uncommon aspect, and it resembles so closely the specimens from Alaska that there can be no doubt that they belong to the same species. The general aspect is somewhat like that of Thinnfeldia.

The specimens collected by Mr. Dumars show that the plant must have been of large size and that it was probably arborescent. One of Dumars's imprints, with much of the lower and upper parts wanting, shows a compound pinna 32 cm. long, with a rachis of the maximum width of 5 mm. This is probably a fragment of a pinna and not of the frond. The specimens are not very well preserved, as the rock is unfavorable, being a sandstone with little tendency to cleave. The pinnules are generally a good deal distorted and fragmentary, so that their normal character can be made out only by a careful examination of all the parts and by taking many pinnules. The large fragment represented in Pl. XLI, Fig. 1, is probably a compound pinna from well down on the frond. The plant is somewhat different in aspect, according to the position on the frond of the parts. The following may be given as its character:

The plant was probably arborescent and of large size. At least a tripinnate character is indicated. The pinnæ of superior order must have had a very considerable length, as indicated in the fragment 32 cm. long, which was probably originally twice as long. This is probably only a penultimate pinna. The ultimate pinnæ in middle portions of the frond, as shown in Pl. XLI, Fig. 1, are short in proportion to the size of the pinnules. None are shown entire, but a few are almost so. The largest of these is 85 mm. long. They go off obliquely from the main rachis and curve slightly away from it. The pinnules were thick in texture and apparently leathery. The largest pinnules, in basal portions of the lower pinnæ, are about 2 cm. long and 9 mm. wide in the widest part. They diminish in width and length toward the ends of the ultimate pinnæ and in terminal portions of the compound pinnæ. Some of the pinnules of larger size are 25 mm. long and only 8 mm. wide, but this variation is probably due to distortion from pressure. The distortion and mutilation of the pinnules seem universal, and it is impossible to find a single one not affected. Hence the specimens, when drawn as they now

are, give a false idea of their original shape and true appearance. The magnified figures of the pinnules and lobes, Pl. XLI, Figs. 4, 5, are slightly restored, so as to give the undistorted forms. In the large penultimate pinnæ, as given in Pl. XLI, Fig. 1, which probably belong to the middle portion of the frond, the true shape of the larger pinnules is ovate to ovate oblong. They are slightly falcate and have lancet-shaped, subacute to acute tips. They are set obliquely on the rachis and point slightly forward toward the ends of the ultimate pinnæ. They are united at base by a decurrence of their dorsal bases. The lower pinnules of lower ultimate pinnæ are least united. Toward the ends of the ultimate pinnæ and in the terminal portions of the compound ones they are more and more united and pass into lobes and teeth, the size being at the same time diminished. They are shown enlarged in Pl. XLI, Figs. 2, 3.

Pl. XLI, Fig. 5, shows, slightly magnified and restored, a portion of an upper ultimate pinna where the pinnules are more united and reduced to lobes. Fig. 4, also slightly magnified and restored, gives the true shape of one of the larger pinnules.

The midnerve goes off very obliquely, and at about two-thirds of the distance to the end of the pinnule splits up into branches after the fashion of Cladophlebis, so that the plant is a well-marked type of that genus, and in the absence of fructification must be placed in it. The lateral nerves, in proportion to the size of the pinnules, are quite slender. They are immersed in the leaf substance and are not conspicuous. They go off very obliquely and are forked one or more times. The lowest are the most copiously branched. The forking is notably low down on the nerve, so that the branches are unusually long. On the lower side of the base of the pinnules one or more lateral nerves go off from the main rachis. In the more separated pinnules the lower lateral nerves curve away from the midnerve, but in the lobed and dentate forms the interior basal ones often curve inward toward it.

This description applies to the large compound pinnæ found by Mr. Dumars, which probably come from the middle portion of the frond. Mr. Woolfe found two rock fragments, the ones examined by Lesquereux, that show parts that probably belong to different positions on the frond. One of them, given in Pl. XLII, Fig. 1, is apparently a more terminal portion of a principal pinna, which, lower down, would carry as subor-

dinate pinnæ the large pinnæ such as are given in Pl. XLI, Fig. 1. On this fragment the ultimate pinnæ of the form given in Pl. XLI, Fig. 1, have been reduced to pinnules. These differ somewhat in shape from the pinnules lower down. They are narrower in proportion to their length. Pl. XLII, Fig. 3, shows one slightly restored and magnified. They are all much mutilated and distorted, so that it is difficult to make out their exact original shape. Pl. XLII, Fig. 2, shows an attached pinnule enlarged two diameters. They were probably wider than they now appear to be. The general character, however, of these pinnules is similar to that of those lower down. The ultimate pinnæ of this fragment are quite remote. There are small pinnules, one at least, on the main rachis between the points of attachment of the rachises of the ultimate pinnæ, but owing to the imperfect preservation they are not distinctly shown.

Another rock fragment found by Mr. Woolfe contains two imprints which probably belong to still other portions of the frond. One of these, given in Pl. XLIII, Fig. 1, has its pinnules much distorted in shape. Still they are narrower and probably were more acute than the pinnules shown on Pl. XLII, Fig. 1. The fragment is probably a part of the compound pinna nearer its termination than are any of the other specimens. This fragment shows a small piece of a penultimate rachis, which carries several fragments of ultimate pinnæ, with a number of pinnules. Pinnules on this, too, are borne on the main rachis between the ultimate pinnæ. Pl. XLIII, Fig. 2, shows several attached pinnules enlarged two diameters, and Fig. 3 gives, slightly restored and enlarged, one of the pinnules of this specimen. In contact with this, but not organically connected with it, is the other imprint. This apparently comes from a position on the frond lower than that of any specimen found. It is a fragment of a penultimate pinna, which carries portions of several ultimate ones. These show, with much mutilation and distortion, a number of pinnules that have teeth similar to those on Dunker's plant. The pinnules, however, are somewhat larger than those of that plant and show teeth on both their margins. Pl. XLIII, Fig. 4, represents this imprint; Fig. 5 shows a pinnule enlarged two diameters, and Fig. 6 gives a pinnule of it slightly restored and enlarged. On the same rock fragment there is another specimen of this plant, on a layer deeper in the stone and only partially

exposed. It has pinnules larger than those shown in Pl. XLIII, Fig. 4, and more deeply incised. It evidently comes from a position still lower on the frond.

To judge from the number of specimens of this fern found in the small collections, it was one of the most abundant and characteristic plants of the flora of its time. That it was pretty widely distributed is shown by the fact that two specimens of it occur in the few fossils collected by Mr. Schrader, at a locality 180 miles distant from the places where Messrs. Woolfe and Dumars obtained their fossils. The specimens of Mr. Schrader show several fragments of pinnules that are rather deeply incised into lobes, and also dentate ones. Pl. XLIII, Fig. 7, represents the specimen in Mr. Woolfe's collection which Professor Lesquereux referred to *Asplenium Fœrsteri* Deb. & Ett.

Phylum SPERMATOPHYTA.

Class GYMNOSPERMÆ.

Order CYCADALES.

Family CYCADACEÆ.

Genus PODOZAMITES Friedrich Braun.

PODOZAMITES DISTANTINERVIS Fontaine.

1888. *Podozamites latipennis* Heer. Lesquereux: Proc. U. S. Nat. Mus., Vol. XI, p. 31, pl. xvi, figs. 2, 3.

1888. *Zamites alaskana* Lx.: Op. cit., p. 32, pl. x, fig. 4.

1889. *Podozamites distantinervis* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 179, pl. lxxix, fig. 5; pl. lxxxii, fig. 4; pl. lxxxiii, figs. 1, 2, 6, 7; pl. lxxxiv, figs. 1, 2, 8, 10, 14, 15; pl. lxxxv, figs. 12, 16.

1902. *Podozamites distantinervis* Font. Schrader: Bull. Geol. Soc. Am., Vol. XIII, p. 245.

Several detached leaflets occur in the collections, mostly in the specimens collected by Mr. Woolfe, that seem to be a Podozamites, identical with the form described from the Potomac formation with the name *P. distantinervis*. Two fragments of it occur also among the specimens collected by Mr. Schrader.

Professor Lesquereux identifies most of these specimens with *P. latipennis* Heer, a form in which the leaflets do not terminate at their

bases like these, and have a different shape. One specimen which, in my opinion, belongs to this species, Lesquereux determines as *Zamites alaskana* Lx., a new species. This specimen, given in his paper, pl. x, fig. 4, has, it is true, a sinus at the base of the leaflets resembling that of some Zamites, but it seems to be an accidental shape due to the rupture of the lamina of the leaflet from the summit of the pedicel. Only the lower part of this leaflet is preserved. It is wider than most of the leaflets of this species, as in the part preserved it attains a width of 24 mm. It may really be a fragment of *Podozamites grandifolius* Font. Most of the leaflets of this plant are fragments, but one of the imprints, determined by Lesquereux, is entire and lies near another that is nearly entire. These are shown in Professor Lesquereaux's paper, pl. xvi, fig. 2. They have a maximum width of 18 mm., which is maintained to near the base, where it is narrowed rather abruptly and rounded off with an elliptical shape. The entire leaf narrows gradually near its free end and terminates in a lancet-shaped tip. It is 105 cm. long. The two leaves are slightly curved and have a somewhat ensiform shape. The character seen in these two seems to be found in all the leaflets, for they differ only in length and in proportion of width to length. None show any portion of the pedicel except one of the fragments among Mr. Schrader's specimens. This is too poorly preserved to show more than the fact that it is a portion of the pedicel. Fig. 3 of the same plate gives a portion of a leaflet occurring on the same rock fragment that carries the leaflets given in fig. 2. This shows very perfectly the terminal portion of the form. It seems to be a leaflet somewhat shorter than the leaflets in fig. 2, but there is no great difference in the length of any of the leaflets. I have identified this plant with *Podozamites distantinervis*, a Lower Cretaceous fossil, but it should be stated that, except in dimensions, the leaflets resemble some forms of *P. lanceolatus Eichwaldi* (Schimp.) Heer and *P. lanceolatus latifolius* (Fr. Br.) Heer[a] that Heer has described from the Jurassic of Siberia. They may especially be compared with the figures given on pl. xxvi. These are, however, decidedly smaller than the leaflets of the Alaskan fossil, with the possible exception of fig. 6. This seems to be a fragment of a large leaflet, which may not be *P. lanceolatus latifolius* (Fr. Br.) Heer.

[a] Fl Foss. Arct., Vol. IV, Pt. II (Beiträge zur Jura-Fl. Ostsibiriens und d. Amurlandes), p. 109, pl. xxvi, figs. 5, 6, 8b, c.

PODOZAMITES GRANDIFOLIUS Fontaine?

Pl. XLIV, Fig. 1.

1888. *Baiera palmata* Heer. Lesquereux: Proc. U. S. Nat. Mus., Vol. XI, p. 31, pl. xvi, fig. 4 (quoad Cat. U. S. Nat. Mus., No. 2437, Lesquereux's Nos. 910, 911a.)

1889. *Podozamites grandifolius* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 180, pl. lxxxii, figs. 2, 2a; pl. lxxxiii, fig. 5.

In the collection made by Mr. Woolfe there are several specimens showing fragments of what must have been a very large leaflet. Lesquereux identified most of these with *Baiera palmata* Heer, a Jurassic plant. He seems to have been induced to make this determination by the fact that one of the leaflets shows a split at one end, extending a little way down toward the base. Only one of the impressions shows this. A careful examination of it indicates that this is an accidental fission and that the forms before mutilation were entire. Lesquereux's figure is therefore erroneous in this particular. The plant is quite problematic and I am not sure of its true character. The leaflets are too imperfect for a correct determination. They appear to be nearer Podozamites than any other fossil. One of the specimens shows a terminal part. This, given in Pl. XLIV, Fig. 1, must have been a very large leaf. The end shown in it seems to be the free end or termination of the leaflet. At the opposite end it is mutilated and much of the length is lacking. Still, it shows a length of 9 cm. and a width at the broken end of 3 cm., allowing for the splitting which occurs here. The specimen figured by Lesquereux, although imperfect at both ends, shows a length of 11 cm., with one margin nearly entire. This specimen shows conclusively that the plant is not a Baiera, but indicates strongly that it is a leaflet of the form of Podozamites. This margin is slightly curved and indicates that the leaflet may have been ensiform. The only forms resembling this plant are those of *Podozamites grandifolius* of the Potomac beds. The size of the leaflets and the form, so far as it is indicated in this specimen, are strongly suggestive of the Potomac fossil. The nerves are not well preserved, but so far as they can be made out they agree well with those of the Potomac plant. They seem to be strong and flat, apparently made up of two nerve strands. On the same piece of rock and partly overlapping this specimen is the impression of a leaf of *Nageiopsis longifolia* Font., to be mentioned below.

Order GINKGOALES.

Family GINKGOACEÆ.

Genus BAIERA Friedrich Braun.

Baiera gracilis (Bean) Bunbury.

Pl. XLIV, Fig. 2.

1843. *Schizopteris gracilis* Bean in Morris: Cat. Brit. Foss., p. 20 (from Bean's manuscript).
1849. *Baiera* sp. Brongn.: Tableau, p. 38 (fide Bunbury: Quart. Journ. Geol. Soc. London, Vol. VII, p. 182).
1851. *Baiera gracilis* (Bean) Bunbury: Quart. Journ. Geol. Soc. London, Vol. VII, p. 182, pl. xii, fig. 3.
1865. *Cyclopteris gracilis* (Bean) Zign.: Osserv. sulle Felci Foss. dell'Oolite, p. 22.
1878. *Schizopteris digitata* Willn. [non (Brongn.) Gein.] in Saporta: Plantes Jurassiques, Vol. III, pp. 277, 279.
1902. *Baiera gracilis* (Bean) Bunb. Schrader: Bull. Geol. Soc. Am., Vol. XIII, p. 245.

In the collection made by Mr. Schrader there is a single specimen that agrees exactly with *Baiera gracilis* (Bean) Bunb. It shows a portion of a long petiole which bears at its summit two equal segments. These divide dichotomously into several narrow laminæ, which are preserved for only a portion of their length. The specimen shows especially a striking resemblance to the figure of this Baiera given by Seward in his Jurassic Flora of the Yorkshire Coast, pl. ix, fig. 5. It resembles *B. Muensteriana* (Presl) Heer of the Rhetic formation, and Seward points out the resemblance of some of the forms of *B. gracilis* to that plant.

Genus GINKGODIUM Yokoyama.

Ginkgodium ? alaskense Fontaine.

Pl. XLIV, Figs. 3, 4.

1888. *Baiera palmata* Heer. Lesquereux: Proc. U. S. Nat. Mus., Vol. XI, p. 31, pl. xvi, fig. 5.

Two fragments of peculiar leaves occur in the collections, one in the collection of Mr. Woolfe and one in that of Mr. Dumars. The specimen found by Mr. Woolfe was determined by Lesquereux as *Baiera*

palmata Heer and figured in his paper, pl. xvi, fig. 5. It, however, shows no trace of a division of the lamina of the leaf. The other, given in Pl. XLIV, Fig. 3, was obtained by Mr. Dumars. Both give the basal parts with a portion of the petiole. These leaves lack their terminal parts. They narrow gradually to a wedge-shaped base and expand to a fan shape in the opposite direction. They show no division of the lamina in the parts preserved, but may higher up have been palmately divided. The base, in its prolonged wedge shape, differs from the Ginkgo leaves associated with these forms, but the principal difference is in the nerves. These are shown with some distinctness in Pl. XLIV, Fig. 3. Fig. 4 shows the nature of the nerves. The margins are thickened to form a parent nerve that sends off, very obliquely, secondary nerves that enter the lamina of the leaf. They fork at their insertions and then are mostly single. Occasionally at long intervals a second forking occurs, but this is very rare. The branches are approximately parallel, diverging slightly in ascending in the leaf. They are quite strong. The nerves of the central part of the leaf ascend from the top of the petiole. In many respects these leaves are like the genus Ginkgodium, established by Yokoyama for certain forms from the Jurassic of Japan.[a] But the Japanese plants have slender nerves that do not fork at all. They go off from the marginal nerve straight to the summit of the leaf and are parallel to the axis of the leaf. As, however, Yokoyama found only one species, it is possible that the limits of variation of the genus may include the Alaskan species.

This fossil resembles also the forms described from the Permian of southwest Pennsylvania and West Virginia as Saportæa.[b] This has the marginal nerves and the branching lateral ones, but the differences are too great to permit these leaves to be placed in that genus. The material is so imperfect and small in amount that the Alaskan fossil can not be positively identified with Ginkgodium.

[a] Jurassic plants from Kaga, etc.: Jour. Coll. Sci. Imp. Univ. Japan, Vol. III, Pt. I, pp. 56–58, pl. ii, fig 4e; pl. iii, fig. 7; pl. viii; pl. ix, figs. 1–10, 10a; pl. xii, figs. 14, 15.

[b] The Permian or Upper Carboniferous flora of West Virginia, by Wm. M. Fontaine and I. C. White: Second Geol. Survey Pennsylvania, Report of Progress, PP, 1880, pp. 99–103, pl. xxxviii, figs. 1–4.

Genus GINKGO Kaempfer.

GINKGO DIGITATA (Brongniart) Heer.[a]

Pl. XLIV, Figs. 5, 6.

Several specimens of a Ginkgo occur in the collection of Mr. Dumars, which in general character agree well enough with *Ginkgo digitata* to be placed in this species. The leaf represented in Pl. XLIV, Fig. 5, probably had a somewhat different form from that now shown. It is mutilated at the summit and slightly distorted at base. The free ends of the lobes appear truncated, but this may be due to the removal of the tips in splitting the rock. This leaf has four divisions and evidently had originally no more. They are irregular in width, and three of them are considerably wider than the lobes of the leaf collected by Mr. Woolfe and figured by Lesquereux in his paper, pl. xvi, fig. 6. This leaf is also less deeply divided and a portion of a stout petiole is shown. Another specimen, more imperfect than these, gives a transition from the one to the other. This is shown in Pl. XLIV, Fig. 6.

GINKGO HUTTONI (Sternberg) Heer.[b]

1888. *Ginkgo multinervis* Heer. Lesquereux: Proc. U. S. Nat. Mus., Vol. XI, p. 31, pl. xvi, fig. 6.

One specimen probably belonging to this species occurs in Mr. Woolfe's collection. Lesquereux identified it with *Ginkgo multinervis* Heer from the Cenomanian beds of Atane, Greenland. It has three almost entire partitions, with a fragment of a fourth on the right side. It is, however, obviously incomplete on this side and had at least one more lobe. The leaf is divided almost to the base, and the divisions are obtuse at the free ends, elliptical in form, and narrow to a wedge shape at the base. The dimensions of this specimen agree very well with those of *G. Huttoni*.

GINKGO HUTTONI MAGNIFOLIA Fontaine?[c]

Pl. XLIV, Figs. 7, 8.

In Mr. Dumars's collection there are several imprints of fragments of very large Ginkgo leaves that must have much surpassed in size any

[a] For the full synonymy of this species see pp. 121–122.—L. F. W.

[b] For synonymy of this species see p. 123.—L. F. W.

[c] See p. 124.

known leaves of *Ginkgo digitata*. They closely resemble a large Ginkgo leaf found in the Jurassic (Lower Oolite) flora of Douglas County, Oreg. This form has been described by me as *G. Huttoni magnifolia* (supra, p. 171). The leaves now in question resemble the Oregon plant in their great size, in the irregular width of the divisions of the leaf, in the remoteness of the nerves, and in their great strength. The size of some of these Alaskan leaves makes it improbable that they belong to *G. digitata*. One of the fragments, which has much of the summit of the leaf missing, is still 5 cm. long, while a spread of 7 cm. is shown on one very imperfect specimen. The nerves of these are more remote than those of *G. digitata* and much stronger.

Pl. XLIV, Fig. 7, gives a fragment of one of these leaves which is apparently divided into only two very wide lobes. But even this is not certainly an original partition of the leaf. It has much the appearance of an accidental division. Some idea of the size of the leaf may be obtained from it. Another specimen is given in Fig. 8. In this the divisions are clearly accidental. In it a portion of a stout petiole is shown. As, however, the material is very imperfect, the true place of the forms can not be positively determined.

Order PINALES.

Family TAXACEÆ.

Genus NAGEIOPSIS Fontaine.

Nageiopsis longifolia Fontaine.

Pl. XLV, Figs. 1–5.

1887. *Irites alaskana* Lx.: Proc. U. S. Nat. Mus., Vol. X, p. 36.[a]

1888. *Baiera palmata* Heer. Lesquereux: Op. cit., Vol. XI, p. 31 in part, quoad Cat. U. S. Nat. Mus., No. 2437, Lesquereux's No. 911.[b]

[a] The four specimens thus named by Professor Lesquereux were collected by Mr. Woolfe but were either received in advance of the main collection or otherwise became separated from it and were sent to Lesquereux and described by him a year earlier than the rest. They were overlooked in sending the collections to Professor Fontaine and not included in his report. They were subsequently sent to him, and in his letter dated March 17, 1902, he says of them: "The specimens sent last do not call for any modification of my report, as they are all *Nageiopsis longifolia*." The best specimen is shown in Pl. XLV, Fig. 5.—L. F. W.

[b] Although Professor Fontaine says that Lesquereux did not mention the specimens of this species in Mr Woolfe's collection, nevertheless he labeled the one having Lesquereux's No. 911 *Nageiopsis longifolia*. This was one of those that Lesquereux referred to *Baiera palmata* Heer. It is here represented in Pl. XLV, Fig. 2.—L. F. W

1889. *Nageiopsis longifolia* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 195, pl. lxxv, figs. 1, 1a, 1b; pl. lxxvi, figs. 2–6; pl. lxxvii, figs. 1, 2; pl. lxxviii, figs. 1–5; pl. lxxix, fig. 7; pl. lxxxv, figs. 1, 2, 8, 9.

1902. *Nageiopsis longifolia* Font. Schrader: Bull. Geol. Soc. Am., Vol. XIII, p. 245.

A considerable number of fragments of detached, narrow, strap-shaped leaflets occur in all the collections. All of those in Mr. Schrader's collection are found on a single rock fragment. Lesquereux does not seem to have noticed those in Mr. Woolfe's collection. At least he gives no description of them. He may have regarded them as forms of *Podozamites latipennis* Heer, but they are quite different from some of the fossils he identified with this species. They are uniformly narrow and for most of the length of the fragments do not differ in width, so that the margins are parallel. They also narrow more at base than the true *P. latipennis*, and seem to have been attached by a short pedicel, which is not the case with Heer's plant. None of these leaflets are complete. They all lack the terminal parts. As none of them are attached, and in only one case is the basal end visible, it is not possible to determine them positively.

The fragment occurring on one of the rock specimens obtained by Mr. Dumars shows a length of 10 cm., with both the basal and the terminal portions lacking. The average width is 11 mm., which it maintains to near one end, where it is narrowed to 9 mm. This is apparently the basal end, but a portion is still lacking here. This is given in Pl. XLV, Fig. 1. The nerves are rather remote. They are parallel and, as shown in one of the imprints in which the base is preserved, fork only on leaving the pedicel. Most of the imprints are shorter fragments in which the margins of the leaflets and the nerves are parallel. The width of the leaflet given in Fig. 1 seems to be the average one, but there are narrower ones, having a width of 7 mm., and wider ones, with a width of 14 mm. One of these larger leaves is shown in Fig. 2. This has a length of 95 mm. It narrows at one end to 7 mm., after the fashion of the one shown in Fig. 1. This represents the specimen referred by Lesquereux to *Baiera palmata* Heer. One of the smaller leaves, with a maximum width of 7 mm., is shown in Fig. 3. This occurs on one of the rock fragments obtained by Mr. Schrader. It shows the base of the leaflet and the mode of narrowing and rounding off there, but the pedicel is lacking. This specimen gives the base better preserved

than any other. It shows also the nerves very distinctly. Fig. 4 represents the basal portion of the principal impression enlarged two diameters.

In the mutilated condition of the leaflets and their detached character it is not possible positively to determine the place of this plant. It agrees well with the conifer *Nageiopsis longifolia*,[a] first found in the Potomac formation. Some of the leaves are rather wider, but the difference is not great. The widest of the Potomac leaves are 12 mm. wide. The leaflets agree especially well with those of figs. 2 and 5 on pl. lxxvi of the work just cited. The nerves also agree well with those of the Potomac plant. They are sharply defined and rather remote. They are parallel and simple to the base of the leaflets. At the base, on entering the pedicel, they fork once and converge by curving sharply. The considerable number of fragments shows that the plant was not uncommon.

CONCLUSIONS.

In the outset it should be stated that the amount of material in these collections is quite small. Much of that obtained is very imperfect. A large portion of it is composed of two or three species, and there is a lack of decisive fossils. Hence it would be understood that any conclusions that may be drawn will be subject to doubt.

The following is the list of plants which have any significance:

1. Dicksonia Saportana Heer. One specimen.
2. Onychiopsis psilotoides (Stokes & Webb) Ward. Several specimens.
3. Cladophlebis vaccensis Ward. One specimen.
4. Cladophlebis alata Font. Many specimens in proportion.
5. Cladophlebis Huttoni (Dunk.) Font. Proportionally many specimens.
6. Podozamites distantinervis Font. Several specimens.
7. Podozamites grandifolius Font.? Several specimens.
8. Baiera gracilis (Bean) Bunb. One specimen.
9. Ginkgodium ? alaskense Font. Two specimens.
10. Ginkgo digitata (Brongn.) Heer. Several specimens.
11. Ginkgo Huttoni (Sternb.) Heer. One specimen.
12. Ginkgo Huttoni magnifolia Font.? Several specimens.
13. Nageiopsis longifolia Font. Proportionally a good many.

These thirteen forms are by no means equal in value for determining age. They differ much in the number of specimens and in the definiteness

[a] Potomac or Younger Mesozoic flora: Monogr. U. S. Geol. Surv., Vol. XV, pp. 195, 196, pl. lxxv, fig. 1; pl. lxxvi, figs. 2–6; pl. lxxvii, figs. 1, 2; pl. lxxviii, figs. 1–5; pl. lxxix, fig. 7; pl. xxxv, figs. 1, 2, 8, 9.

of their determination. To have value in determining age the mere presence of the species is not all that is required. The plant must be abundant in the flora and characteristic of it. It may be a survivor from an older flora. The proportion of specimens in a collection is the only feature that gives a hint on these points. It of course must not be insisted on too strongly, for there are other conditions besides the actual relative abundance that may give a large proportion of the specimens to one species. *Cladophlebis vaccensis, Dicksonia Saportana, Ginkgo digitata, G. Huttoni magnifolia?,* and *Baiera gracilis* are notably fossils of the Lower Oolite. *Ginkgodium? alaskense* is a new species, and if it be a true Ginkgodium, its nearest kin is found only in the same formation.

On the other hand, the following belong to the Lower Cretaceous, taking the Wealden as belonging to that formation: *Cladophlebis alata, C. Huttoni, Onychiopsis psilotoides, Podozamites distantinervis, P. grandifolius?, Nageiopsis longifolia.*

These plants are, as stated, not of equal value in determining age. *Cladophlebis vaccensis, Dicksonia Saportana,* and *Baiera gracilis* have each only one specimen. Hence we may conclude that they were not abundant in the flora, and they may be survivors from an older one. *Podozamites grandifolius?* and *Ginkgo Huttoni magnifolia?* are not positively determined. Leaving these and the probable Ginkgodium out of the question, we have, as the fossils of most value for fixing the age, five plants, viz, *Cladophlebis alata, Onychiopsis psilotoides, Cladophlebis Huttoni Podozamites distantinervis, Ginkgo digitata,* a very small list.

The *Cladophlebis psilotoides* shows some differences from most of the described Lower Cretaceous forms, which somewhat impair its value as evidence. *Cladophlebis alata* and *C. Huttoni,* if we may judge from the number of their specimens, must have been abundant and highly characteristic of the Alaskan flora of their time. All of the more important plants except *Ginkgo digitata* are Lower Cretaceous, and if we take simply their percentage in the flora the evidence is overwhelming in favor of the Lower Cretaceous.

I am, however, inclined to attach great weight to the considerable proportion of Ginkgos of Jurassic type.

The Ginkgos in Lower Oolitic times were immensely developed in the Amur region in Siberia and in the northwestern part of the United States,

showing a remarkable resemblance in their forms. The resemblance is such as to suggest land connection in the lower Oolite epoch between Asia and North America and a common flora.

In Lower Cretaceous times, however, they had become nearly extinct on the American continent, even in those parts where they had been so prominent in the Lower Oolite. In all the Lower Cretaceous flora of the northwestern region the only Ginkgo found occurs in the Kootanie beds of Canada. Sir William Dawson, in his Mesozoic Floras of the Rocky Mountain Region of Canada,[a] describes three fossils which he regards as Ginkgos. One of these, given on pl. ii, fig. 1, he identifies with *G. sibirica* Heer; another, shown on pl. ii, fig. 2, he determines as *G. lepida* Heer; and a third, depicted on pl. ii, fig. 3, he names *G. nana*. His *G. lepida* and *G. nana* are evidently not Ginkgos, but are probably a Baiera, and both the same species. His *Ginkgo sibirica* is a true Ginkgo and may be that species. It is the sole survivor apparently and is much smaller than most of the types common in the Lower Oolite. In the Alaskan fossils the relative abundance of the specimens of the two Ginkgos shows this type of plant is still present in force. The large size of the leaves shows that it is probably still in full vigor. This indicates that the time in which these Ginkgos lived in Alaska is not so late as the Lower Cretaceous. The characteristic Lower Oolitic forms still constitute a large element in the flora.

The floras of the different parts of the northern hemisphere in the Lower Oolite and the Wealden are comparatively well known; the vegetation of the intervening time, especially in its foliage, is little known. It is probable that many of the Jurassic types found in the Wealden or Lower Cretaceous flourished in the Upper Oolite and survived in the Lower Cretaceous. The finding, then, in a locality of such Lower Cretaceous forms as *Cladophlebis alata, Onychiopsis psilotoides, Cladophlebis Huttoni*, etc., does not necessarily prove a Lower Cretaceous age.

The age of the formation yielding the Alaskan fossils, as indicated by them, is not older than the Lower Oolite, and not younger than the Lower Cretaceous, but is probably between them.

[a] Trans. Roy. Soc. Canada, Sect. IV, Vol. III, 1885, p. 8.

5. PLANTS FROM NORTHERN CALIFORNIA.

[Under date of December 26, 1901, Professor Fontaine reported as follows upon the collection made by Mr. Storrs in Trinity County, Cal.—L. F. W.]

I have examined the specimens collected by Storrs from California, 2 miles northwest of Slatonis. Most of them are shale fragments, with distinct cleavage, and all have a more or less pronounced cleavage. Nearly all of the imprints have suffered so much from maceration that they show no character. They have evidently drifted far from their place of growth.

BRACHYPHYLLUM? STORRSII Ward n. sp.[a]

Pl. XLV, Fig. 6.

1903. *Brachyphyllum ?* sp. Font. in Diller: Am. Journ. Sci., 4th ser., Vol. XV, p. 352.

The best preserved imprints are cones which, in some cases, preserve enough of the plant tissue to give an idea of their nature. The best preserved of them have been much compressed and distorted by pressure, which has caused a creep of the plant substance along the planes of cleavage, so that it is impossible to determine positively even their generic character.

Besides the cones there are some poorly preserved bits of twigs which probably belong to the same plant as the cones. There is a great difference in the size of the cones. Some of them seem to be mature, some immature, and there appear to be some male strobiles. All the imprints which show any recognizable features are strongly suggestive of Brachyphyllum. They may, however, belong to the genus which I described as *Pagiophyllum dubium* from the Comanche of Texas,[b] which Nathorst makes a new genus, Pseudofrenelopsis.[c] If the cones belong to Pseudofrenelopsis the species is probably different from the Comanche form, for the cones now in question are decidedly larger. Their true size, however, is not given in their present form, for they are mostly broadened by the creep of the shale. The same creep has greatly distorted the form of the cone scales.

[a] As Professor Fontaine does not assign to this plant any specific name, and as it is likely to be the subject of future discussion, I propose for it the name *Brachyphyllum ? Storrsii*, for the collector.—L. F. W.

[b] Notes on some fossil plants from the Trinity division of the Comanche series of Texas: Proc. U. S. Nat. Mus., Vol. XVI, pp. 261–282. See p. 271, pl. xxxix, figs. 2–11.

[c] Beitr. zur Geologie und Paläontologie der Republik Mexico, von J. Felix und H. Lenk, Leipzig, 1893, II. Theil, 1. Heft, pp. 51–54.

Some few of these are shown with little distortion, and they resemble those of Brachyphyllum; that is, they are thick and rhombic in form, with the greater dimensions transverse to the axis of the cone. Most of them, however, are in this transverse direction so much elongated and distorted that they appear as parallel raised lines. The mature cones may be compared with the cone B. *Moreauanum* Brongn., as given by Saporta in Paléontologie Française, Plantes Jurassiques, Vol. III, pl. xxxix, fig. 2. They are, however, broader than that, which may be due to the distortion transverse to the axis of the cones. The cone scales are larger than those of *B. Moreauanum*, and the species is probably different. There are also, as stated, obscure bits of twigs, which appear to belong to the same plant as that carrying the cones. They are mostly decorticated, but a few show vague traces of leaf scars similar to those of Brachyphyllum.

The apparent strobiles are small cylindrical fragments with chaffy scales. They probably belong to the plant that shows the larger mature cones. There are several small elliptical to globose cones that are much smaller than the mature ones. They apparently have the same kind of cone scales as the larger cones, but smaller and thinner. These may be immature cones of the plant carrying the larger cones, the male strobiles, and the leafy twigs.

Brachyphyllum is most developed in the Jurassic and Lower Cretaceous. If we may regard this plant as belonging to that genus, then, so far as its evidence goes, the strata are Jurassic or Lower Cretaceous. But as the generic place of the fossil can not be determined positively, and the amount of material is so small, the age can not be certainly fixed.

6. *PLANTS FROM NORTHERN MONTANA.*

Sequoia Reichenbachi (Geinitz) Heer.[a]

Pl. XLV, Figs. 7, 8.

This specimen was obtained by Dr. A. C. Peale from the east slope of the Bridger Range, north of Bridger Creek, Montana, and is labeled by Doctor Peale as Jurassic. Professor Ward gives as the more exact locality 4 miles northeast of Bozeman, Mont., on the right bank of Bridger Creek. The fossil is a small bit of a twig 25 mm. long, with a

[a] For the synonymy of this species see Nineteenth Ann. Rep. U. S. Geol. Surv., Pt. II, 1899, p. 674.

number of fairly well-preserved leaves. It is clearly a Sequoia, and is most probably *S. Reichenbachi*, as the leaves have the size, shape, and mode of insertion of those of that species. It indicates that if the formation containing it is Jurassic it is the upper part of it. But it may well be Lower Cretaceous.

7. PLANTS FROM SLATE SPRINGS, MONTEREY COAST, CALIFORNIA.

SEQUOIA FAIRBANKSI Fontaine n. sp.

Pl. XLV, Figs. 9–11.

This is the plant referred to in Pt. II of the Twentieth Annual Report of the United States Geological Survey, pp. 338, 339. Four specimens were obtained, one of which shows no character. They were collected by Mr. H. W. Fairbanks from Slate Springs, California, in rocks underlying the Knoxville group of the Lower Cretaceous. The specimens are poorly preserved and have suffered from maceration.

The form given in Pl. XLV, Fig. 9, is a fragment of the largest leafy branch that was found. The leaves are poorly preserved and pressed close to the stem, so that they can not be seen distinct from it. They seem, however, to have the long slender form that is better shown in the specimen depicted in Fig. 10. The stem given in Fig. 9 seems to have had a diameter of 5 mm. Fig. 10 represents a much smaller twig. This is 65 mm. long and 15 mm. thick. It carries scattered along its length a number of developed leaves and at its end a number of undeveloped ones, forming a bunch similar to those shown on the small twig depicted in Fig. 11. The developed leaves, as shown in Fig. 11, may, for description, be taken as the normal ones. They are a good deal like those of *Sequoia Reichenbachi*, and the plant is apparently a sequoia of the *Reichenbachi* type. The leaves are 15–20 mm. long. They narrow very gradually to an acute point and widen toward the base. They are decurrent and strongly incurved, showing a slender midrib. They are more slender and thinner in texture than the leaves of *S. Reichenbachi*. Fig. 11 gives the terminal portion of a small twig on which the leaves appear to be undeveloped. These leaves are very narrow, short, and straight. They are pressed closely to the stem.

The plant is not unlike those from the Jurassic, called by Heer Elatides, and may be compared with *E. falcata*,[a] but the leaves are larger than those of that plant. It may be fittingly named from its discoverer *Sequoia Fairbanksi*.

JURASSIC CYCADS FROM WYOMING.

Since the appearance of the first paper of this series, in which all the Jurassic cycads from the Freezeout Hills of Wyoming that were known to me at that time were described and figured,[b] two additional invoices of material from the same restricted bed have been sent to the National Museum by Professor Knight under the same conditions as those relating to the first invoice. The former of these invoices consists of the collection made by me on the occasion of my visit to the locality in 1899, an account of which is given in the first paper, but the full treatment of the collection could not be then made, as it was necessary to go to press with the paper before the collection could be studied (see p. 387 of that paper). As soon as I found time, however, I had the collection unpacked and the specimens numbered according to Professor Knight's instructions. These were to continue the numbering from the last number of the first invoice as far as the specimens extended. The numbering was on the basis of 500, and the first invoice included Nos. 500.1 to 500.87, although these numbers included several specimens of fossil wood and one bone taken from the same bed, the latter not sent with the cycads.

Only a few large specimens or nearly complete trunks were found by me and the collection consisted chiefly of fragments, many of them quite small, some of them mere chips or splinters. I was careful to save almost everything that could be seen certainly to belong to a cycadean trunk, in the hope that, coming as they did from the same bed, a few of them might be found to be the missing parts of incomplete trunks in the first invoice. In this, as will be seen, I was not mistaken, although the result is not so satisfactory as might perhaps have been expected. The number of such small fragments was very large, and when they were all numbered they extended the list from No. 500.88 to 500.687, including therefore, by a curious coincidence, just 600 specimens.

[a] Fl. Foss. Arct., Vol. IV, Pt. II (Jura-Fl. Ostsibiriens), pp. 79–80, pl. xiv, figs. 6, 6b, 6d.

[b] Twentieth Ann. Rep. U. S. Geol. Surv., Pt. II, 1900, pp. 382–417, pl. lxx–clxxvii.

Mention was made in the first paper (p. 387) of a collection that had been made by Mr. Charles Gilmore before my arrival. This, I was told, was stored in a building in Medicine Bow, but as our party hurried through that place to reach the field, I did not take time to hunt it up and examine it. It was expected that an effort would be made to increase the collections by plowing the ground deeply with a subsoil plow, as might easily be done. I had dug out a number of fine trunks with my mattock that were not visible from the surface, but this process was slow and laborious, and it was thought that such subsoil plowing might reveal many more.

At the close of 1902 I learned from Professor Knight that the University of Wyoming had arranged with the Carnegie Museum to plow the ground on which the cycads were found and divide the results between the two institutions, but that the degree of success was not what had been anticipated. Professor Knight stated that before the ground was plowed he had found "one of the finest specimens that has ever been taken from the place." This I have not yet seen. He sent me, however, as one of the results of the plowing, a fine terminal bud, which he thought might be a cone. As nearly as I can judge, it belongs to *Cycadella jurassica,* and at his suggestion I have given it the next number of the museum of the University of Wyoming, first series, which is 500.688.

On March 20, 1903, Dr. T. W. Stanton turned over to me a specimen collected by W. T. Lee from the same bed in the Freezeout Hills. It is a small fragment from the side of a large trunk showing half a dozen large scars that indicate that the trunk was that of *Cycadella wyomingensis.* It is deposited in the National Museum with the locality number, 3050, of the United States Geological Survey.

During the summer of 1901 a third invoice arrived, purporting to contain all the specimens collected to that date. The larger trunks, at least, are doubtless the ones previously collected by Mr. Gilmore, but nearly all the specimens in this invoice are fair-sized fragments, and there are very few small pieces, such as many that I saved.

This last collection was numbered before it was shipped and on a different basis. It bears the numbers of the Museum of the University of Wyoming from No. 100.201 to No. 100.353, thus containing 153 specimens. There are, therefore, in the additional material to be studied 753 specimens, great and small. Yet in all this there are not a dozen trunks that

are even approximately complete. The rest are fragments of all sizes, but many of them very small, the least weighing no more than 5 or 6 grammes. Many of the latter, however, show the internal structure very clearly, and when the time arrives for making a study of them from microscopic preparations these will yield excellent results.

In view of these last-mentioned considerations, and also in the hope of finding as many pieces complementary to the originally described types as possible, I thought it worth while to make a somewhat careful study of all this material, and I therefore devoted to it a considerable part of my time from September 23 to December 31, 1901. The original types were laid out in a conspicuous position and arranged by species for comparison, and the later collections were then similarly exposed and first arranged by numbers. Before any satisfactory results could be reached it was found necessary, as in the case of the original collection, to clean the specimens with hydrochloric acid and remove the incrustation of lime that obscured the structure of the majority of them. This was done simultaneously with their study. At first it seemed that only a very few could be identified with described species on account of their fragmentary character, but prolonged and minute inspection and comparison with the types gradually revealed characters that could not otherwise be detected, and finally enabled me to venture a provisional reference in the case of a large number to the species described in the first paper. The question whether the new material contains any additional species beyond the twenty species previously described can not be definitely settled, but I incline to think that some of the fragments belong to species different from those of the first collection. This, however, is not certain from the scanty material, and I have therefore referred such with doubt to the species that they most closely resemble. It does not seem that any of the complete trunks or large characteristic fragments belong to new species, although some of them possess characters not seen in the original types. This is notably the case with those that I am obliged to refer to species founded on only one or two specimens, but in such cases this was to be expected.

I shall take up the species in the same order in which they were treated in the first paper and make such additional notes on each as the study of the later material calls for. In view of the probability that the specimens will be one day taken up and subjected to microscopic study from the

standpoint of internal structure, I shall append to my notes on each species a list of the numbers of specimens that I provisionally refer to it. This may prove useful as a basis for such work, although I do not doubt that the study of their internal structure will require many changes in the classification. I therefore do this at the risk of having many errors—if such they can be called—subsequently corrected, but as all references must be regarded as provisional, and as the extremely fragmentary character of the material makes certainty unattainable, I am sure that due allowance will be made and that no one will attribute necessary changes to carelessness on my part.

Genus CYCADELLA Ward.

1900. *Cycadella* Ward: Proc. Wash. Acad. Sci., Vol. I, p. 263, pl. xiv; Twentieth Ann. Rep. U. S. Geol. Surv., 1898–99, Pt. II, p. 392, pl. lxx.

All the specimens of the two collections under consideration belong to the genus Cycadella, and none of them certainly represent species not already described.

CYCADELLA REEDII Ward.

Pl. XLVII, Fig. 3.

1900. *Cycadella Reedii* Ward: Proc. Wash. Acad. Sci., Vol. I, p. 264, pl. xv; Twentieth Ann. Rep. U. S. Geol. Surv., 1898–99, Pt. II, p. 393, pl. lxxi–lxxvi.

An unexpectedly large number of fragments had to be referred to this species, most of them more or less doubtfully, but in all cases the characters show a closer relationship to it than to any other described species. They are mostly fragments and there is no complete trunk. They represent small trunks, usually, so far as can be judged from the parts we have, smaller than any of the original type specimens except No. 500.10 (see pl. lxxvi). They are generally from trunks larger than that, but resemble it in other respects more than they do other types. They show variations in the internal structure which may be specific, but as all the type specimens previously described were so nearly complete and the structure was not shown, it is not known what the interior would reveal. There is, however, nothing in any of the fragments referred to this species that conflicts with the description given.

Pl. XLVII, Fig. 3, represents one side of the specimen No. 100.239, which is a fragment weighing 0.47 kg., of which the top and the whole of one side are wanting.

Cycadella Beecheriana Ward.

1900. *Cycadella Beecheriana* Ward: Proc. Wash. Acad. Sci., Vol. I, p. 265, pl. xvi; Twentieth Ann. Rep. U. S. Geol. Surv., 1898–99, Pt. II, p. 394, pl. lxxvii, lxxviii.

None of the specimens in the second and third invoices were referred to this species. The types were not in my hands, being at the Yale University Museum. They consist of No. 128 of that museum and No. 500.54 of the Museum of the University of Wyoming, which I found to be a complement of the former, and which, on this account, Professor Knight gave to Yale to complete the specimen there. Although the species was carefully described and fully figured, and I have a distinct visual impression of its appearance, it is not impossible that if the specimens had been before me I should have provisionally referred to it some of the more aberrant forms.

Cycadella wyomingensis Ward.

Pl. XLVI.

1900. *Cycadella wyomingensis* Ward: Proc. Wash. Acad. Sci., Vol. I, p. 266, pl. xvii; Twentieth Ann. Rep. U. S. Geol. Surv., 1898–99, Pt. II, p. 395, pl. lxxix–xc.

Three large specimens and many smaller ones in the last two invoices are referable either with certainty or with considerable probability to this species. One of the large ones, No. 500.88, consists of one large piece weighing 6.8 kg. and two smaller ones of nearly equal size weighing together 1.9 kg., all bearing the same number, and making a total weight of 8.7 kg. These all fit perfectly together and form more than three-fourths of a very handsome trunk. The basal portion only was wanting, but the greater part of it was found under two other numbers, viz, Nos. 500.513 and 500.525, which were first found to fit each other and afterwards to fit the lost part of the large trunk. No. 500.513 weighs 1.72 kg., while No. 500.525 is a small piece weighing 177 grammes. Putting all these pieces together we have a nearly complete trunk weighing 10.6 kg. The only part lacking is a small notch on one side of the base, which none of the fragments in the collection would fit into. Thus completed this trunk is very nearly the same size as the type specimen No. 500.15 and resembles it in many respects. It is, however, rather more flattened, largest in the middle, where the major diameter is 24 cm. and the minor 13 cm., giving a girth of 59 cm. It stands 36 cm. high.

No. 500.681 represents a much larger trunk, but is much less perfect than the one last described, and none of its missing parts could be found among the fragments. It consists of considerably more than half of the original trunk, which was symmetrically subconical, rounded at the summit, and longitudinally flattened, but to a much less degree than the other. The principal loss is at the base by a rather even transverse fracture, but a large piece is also broken away from one of the thinner sides, the fracture deepening toward the summit and carrying away the apex altogether. It is now 24 cm. high and 18 by 25 cm. in diameter at the basal fracture, and has a girth of 69 cm. It weighs 11.34 kg. This, therefore, represents a larger trunk than any that were originally referred to this species. It also differs in some other respects from the types. The outer coating of ramentum is also wholly removed and the surface thus exposed presents a somewhat different appearance from that of the other specimens. The bases of the petioles rise above the walls so as to give the surface a rough, warty aspect. The rock substance is harder and heavier than that of the other trunks. These differences do not, however, seem to be specific, and I prefer to retain the specimen in this species.

No. 100.227 is a segment from near the base of a still larger trunk. The basal fracture is nearly horizontal, but the upper one is somewhat oblique, so that while the thicker edge is 12 cm. high the thinner edge is only 6 cm. This trunk was also somewhat elliptical, the diameters at the base being 19 cm. and 27 cm., respectively, giving a girth of 74 cm. The segment weighs 8.62 kg. The external surface of this specimen closely resembles that of No. 500.681 and it represents the same general type. These two specimens may ultimately require to be placed in a distinct species.

Pl. XLVI is a side view, also showing part of the base, of the trunk formed by joining Nos. 500.88, 500.513, and 500.525.

A larger number of specimens had to be referred to this species than to any other, but all except those treated above are mere fragments, most of them quite small. Many of these fragments closely resemble the interior of the type specimens Nos. 500.7, 500.8, 500.20, and 500.67, and there can be no doubt that some of them are parts of the same trunk or trunks represented by those specimens, but in only one case has this been proved by finding the complementary parts. This case is that of

the small fragment No. 500.521, weighing 0.14 kg., which fits one of the fractured surfaces of No. 500.7. In one other unimportant case two of the later-acquired fragments proved to be the complements of each other, viz, Nos. 500.176 and 500.229.

Cycadella Knowltoniana Ward.

Pl. XLVII, Figs. 1, 2.

1900. *Cycadella Knowltoniana* Ward: Proc. Wash. Acad. Sci., Vol. I, p. 267, pl. xiv, figs. 1–3; pl. xviii–xx; Twentieth Ann. Rep. U. S. Geol. Surv., 1898–99, Pt. II, p. 396, pl. lxx, figs. 1–3; pl. xci–xcv.

This species, which, although represented by only two specimens in the original collection, furnished the best illustrations of the generic characters, is not absent from the material since received. The two specimens, Nos. 500.94 and 500.498, resemble the type No. 500.76 sufficiently closely to have formed parts of the same trunk, but this is not proved by the discovery of any contiguous surfaces. Like that specimen, they are both somewhat triangular sections bounded by radial fractures, but showing considerable of the outer surface. In both, too, as in the type, it is the transverse fracture that best reveals the structure. If polished in the same way they would both doubtless show all the characters of the genus.

No. 500.94 is 8 cm. high and 13 cm. in diameter, which represents a chord of the circumference, of which the arc is 19 cm., but the surface is very irregular. The trunk was probably 15 cm. in diameter in this direction. The radial thickness is 10 cm., which seems to include more than half of the medulla, but this indicates a diameter in this direction of about 18 cm. The trunk was therefore elliptical. The fragment weighs 1.22 kg.

No. 500.498 is a similar section, but the fractures are all oblique to the axis. It is about 8 cm. high, 12 cm. in tangential direction, and the same in radial direction. It weighs 1.41 kg. The outer coating of ramentum is nearly 2 cm. thick in places, and the armor 3 cm., the petioles and walls contrasting strongly in color, so as to show the structure to good advantage even on the unpolished surface of the fractures.

Two other specimens, Nos. 500.102 and 500.285, are referred to this species, but these are one, since they perfectly fit each other, the latter being only a thin plate lying on one of the fractured planes of the former.

They thus form a rectangular piece from the middle of a trunk, showing the outer surface at both ends. The central part of the radial fracture is bounded by the inner wall of the woody zone and shows striations and markings not widely different from those much better shown in the type specimen, No. 500.62, which were described and figured. These specimens represent a trunk about 14 cm. in diameter.

Pl. XLVII, Figs. 1, 2, show, respectively, the outer surface of Nos. 500.94 and 500.498.

Cycadella compressa Ward.

Pl. XLVII, Fig. 4; Pl. XLVIII.

1900. *Cycadella compressa* Ward: Proc. Wash. Acad. Sci., Vol. I, p. 269; Twentieth Ann. Rep. U. S. Geol. Surv., 1898–99, Pt. II, p. 398, pl. xcvi; pl. xcvii.

Five specimens in the second invoice and four in the third are referred to this species with more than the usual confidence, and a number with certainty. Nos. 100.228, 500.503, and 100.264 are nearly complete small trunks typical of the species. The first of these closely resembles the type No. 500.22 and the second the type No. 500.18. The third is smaller than any of the original types. No. 100.290 is a very small but apparently complete trunk weighing only 0.18 kg., but it has the general character of this species. It may be immature. The other specimens are fragments, but No. 500.132 exactly resembles Nos. 500.68 and 500.69. Most of the rest have the same character. No. 500.503 weighs 0.74 kg.; No. 100.228, 0.75 kg., and No. 100.264, 0.31 kg. Pl. XLVII, Fig. 4, and Pl. XLVIII, Figs. 1, 2, show these three specimens, respectively, from their most characteristic sides.

Cycadella jurassica Ward.

Pl. XLIX.

1900. *Cycadella jurassica* Ward: Proc. Wash. Acad. Sci., Vol. I, p. 270; Twentieth Ann. Rep. U. S. Geol. Surv., 1898–99, Pt. II, p. 399, pl. xcviii–cxii.

No large trunks of this species occur in the later collections, but a very large number of fragments were found which can not be referred elsewhere, and many of them show the typical characters so clearly that there is no serious doubt of their specific identity.

The largest specimen is No. 100.204, weighing 2.1 kg., but this is supplemented by No. 500.507, weighing 0.98 kg., which nearly doubles the area of surface exposed and shows the characters more clearly than any of the original types. The specimen thus reconstructed is a segment from the side of a large trunk, probably near the base, and extending quite to the middle. The diameter, which is still not complete, is 23 cm.

Still more important was the discovery that the large fragment No. 500.511, weighing 1.54 kg., forms part of the type specimen No. 500.38, and exactly matches the fractured face represented in pl. cii of the first paper, completing the upper part. As a surplus of good fortune it was also found that the smaller fragment No. 500.516, weighing 0.65 kg., fits both these specimens in such a manner as to extend the part covered by its entire thickness of about 4 cm. This brings it within 5 cm. of the basal fracture, and we now have over two-thirds of the trunk.

One small specimen, No. 100.250, weighing 0.43 kg., was found to belong to the type specimen No. 500.80, which was itself only a fragment and was not figured. It now becomes a respectable specimen. The other case of complementary parts is that of Nos. 100.289 and 100.292, which are both small specimens, weighing together only 0.23 kg. and showing nothing that is not better shown by other specimens.

Pl. XLIX is a view of the external surface shown in the segment Nos. 100.204 and 500.507.

Cycadella nodosa Ward.

Pl. L; Pl. LI; Pl. LII, Fig. 1.

1900. *Cycadella nodosa* Ward: Proc. Wash. Acad. Sci., Vol. I, p. 271; Twentieth Ann. Rep. U. S. Geol. Surv., 1898–99, Pt. II, p. 401, pl. cxiii–cxxii.

Notwithstanding the small number of specimens in the later collections referable to this species and the fact that none of them supplement the original types, it has proved one of the most satisfactory of the specific groups. This is due to the fact that it contains two complete trunks that are quite as fine as any of the original types and two others that are very nearly complete.

No. 500.509 is a complete trunk weighing 1.65 kg. and closely resembles the type No. 500.47, but is somewhat smaller. It has the con-

tracted base even more clearly marked. No. 100.206 is also complete and weighs 2.83 kg. It closely resembles the type No. 500.17. It is nearly the same size as that specimen, but the rock is less compact and there is some difference in the weight. No. 100.217 lacks the summit but shows the base very well. This was a larger trunk and still weighs 1.59 kg. No. 100.229 is a small, much flattened trunk, complete with the exception of a small piece. It weighs 0.47 kg. Except in size it is nearest to the type No. 500.21. The other two specimens are fragments and their reference to this species is somewhat doubtful.

Pl. L is a side view of No. 500.509 and Pl. LI a side view of No. 100.206. Pl. LII, Fig. 1, shows one of the flattened sides of No. 100.229.

Cycadella cirrata Ward.

Pl. LII, Figs. 2–4; Pl. LIII.

1900. *Cycadella cirrata* Ward: Proc. Wash. Acad. Sci., Vol. I, p. 272; Twentieth Ann. Rep. U. S. Geol. Surv., 1898–99, Pt. II, p. 403, pl. cxxiii–cxxix.

A large number of small fragments in the second and third invoices show the peculiar internal structure of this species, while there is nothing in their general character that negatives their reference to it. There are some others that seem to belong here, but which differ in the character of the rock and in other respects from any of the types. If complete trunks of such had been found, it seems probable that they would have represented one or two new species, but lacking adequate material it seems best to refer them doubtfully to *C. cirrata* for the present. Many of these fragments are found to represent complementary parts of one another, and a still larger number so closely resemble one another in structure that there is scarcely any doubt that they are from the same trunk that has disintegrated into small pieces. There seem to be three or four such trunks, and nearly all the fragments can be referred to one or another of them. One of these trunks is undoubtedly the one to which the type specimens probably all belong (see the discussion following the description), but it has not been possible to find any exactly complementary parts of the types.

The Nos. 500.136, 100.240, and 100.223 all join together in that order, and Nos. 100.210 and 500.569 also join in such a manner as to make it practically certain that they all belong to one trunk and that

only a thin piece is missing between Nos. 500.136 and 100.210. If this were present, we should have nearly half of a small compressed trunk. No. 500.470 joins No. 100.338, and No. 500.594 joins No. 100.312. These last four, with about a dozen other fragments, undoubtedly represent the type trunk, and the structure indicates that they lay very close to the type No. 500.71 (see Pl. cxxviii). Nos. 500.178 and 500.422 constitute another complementary couple of a somewhat different class, but evidently belonging to this species. They show the internal structure very clearly and also considerable of the surface, indicating a much compressed trunk probably larger than that to which the type specimens belong. Nos. 100.258 and 100.275 also go together and represent still another trunk not otherwise represented. They all have the characteristic internal structure and surface markings of the species. No. 100.245 is the largest specimen, weighing 0.9 kg. It is a slab from one side of a trunk, showing considerable of the surface and a broad, smooth, tangential fracture.

Pl. LII, Fig. 2, is a side view of the triangular section resulting from joining Nos. 500.178 and 500.422, and Pl. LII, Fig. 3, the internal structure of the inner fracture of No. 500.422. Pl. LII, Fig. 4, shows one of the fractures of No. 500.136, and Pl. LIII the tangential fracture of No. 100.245.

Cycadella exogena Ward.

Pl. LIV.

1900. *Cycadella exogena* Ward: Proc. Wash. Acad. Sci., Vol. I, p. 273; Twentieth Ann. Rep. U. S. Geol. Surv., 1898–99, Pt. II, p. 404, pl. cxxx–cxxxvii.

A limited number of specimens, most of them fragments, are referred to this species. By far the largest and most complete is No. 500.514, which weighs 2.04 kg., although the armor has disappeared from more than half of it and a considerable part of the axis is also wanting. This specimen is difficult to orient, as neither base nor summit is present and the direction of the axis is not clear, while the surface is covered with ramentum, but one of the fractures which passes through the entire woody zone and the armor was found to join one of the planes of fracture of the small specimen No. 100.249, adding considerable to the trunk. This specimen weighs 0.45 kg., making the total weight

of the combination 2.49 kg. This specimen appears to have been nearly spherical, and somewhat resembles the trunk Nos. 500.19 and 500.53. Like that, the interior is very hard and smooth and the surface is covered with a thick ramentum. Some of the fractures show the exogenous structure quite clearly.

No. 100.220 is another good specimen, representing somewhat more than half of a small trunk and weighing 0.75 kg. The base and one of the sides are well shown and exogenous structure is clearly seen in the irregularly longitudinal fracture.

Nos. 500.293 and 500.388 are two small complementary parts of the armor with regularly curved inner and outer surfaces, having exactly the same thickness and texture of the armor as No. 500.61, as shown in the transverse section, pl. cxxxii, fig. 2, of the first paper. They undoubtedly belong to that trunk and come from a point very near that fractured plane, but they do not exactly join it, and are probably from a somewhat different plane. They can belong nowhere else, as the opposite hemisphere is present in the specimen No. 500.53. These fragments are of unequal size and together weigh only 0.13 kg.

There are two other specimens that complement each other, viz, Nos. 500.416 and 100.253. They are small fragments and weigh together 0.61 kg. They show the ring of woody wedges more distinctly than any other specimen except No. 500.19, but they do not otherwise resemble that trunk and can not be referred to any of the trunks of this species thus far found. There is, however, no doubt that they represent this species. They may possibly belong to the same trunk as the fragment No. 500.174, which also shows the structure and the rings with unusual clearness. That specimen is a small segment from the base of a trunk weighing 0.44 kg. It extends to the medulla, and the fractures show three distinct rings of wood. None of the remaining specimens are specially worthy of comment.

Pl. LIV, Fig. 1, shows the tangential fracture of the first of these adjacent to the corresponding face of the second. Pl. LIV, Fig. 2, shows the internal structure of No. 500.416, and Fig. 3 that of No. 500.174.

Cycadella ramentosa Ward.

Pl. LV; Pl. LXII, fig. 1.

1900. *Cycadella ramentosa* Ward: Proc. Wash. Acad. Sci., Vol. I, p. 275, pl. xiv, figs. 4, 5; Twentieth Ann. Rep. U. S. Geol. Surv., 1898–99, Pt. II, p. 406, pl. lxx, figs. 4, 5; pl. cxxxviii–cxliv.

A large number of fragments are referred to this species, mostly on the strength of the characteristic internal structure, but many are very doubtful and others quite worthless. Several, however, certainly belong to the same trunks as the type specimens, and in two cases this is proved by finding the planes of juncture. These are the specimens Nos. 500.357 and 500.620, the former of which fits the end of No. 500.50, and is in turn matched by the latter, thus extending the type specimen some 8 cm. in one direction. A number of other fragments are undoubtedly parts of the trunk that was built up from the types Nos. 500.40, 500.43, 500.45, 500.66, and 500.81 (see pls. cxl and cxli), and some of these are quite large. No. 100.248 weighs 0.57 kg. and shows the internal structure and external ramentum exceptionally well. It nearly matches No. 500.40. No. 100.219 weighs 0.69 kg. and is very close to No. 500.66, being a triangular piece like No. 500.81. No. 100.243 is similar to the last, but smaller, weighing only 0.37 kg. All of these would join that combination in different ways but for the loss of small chips, many of which are in the collections. No. 100.205, weighing 0.9 kg., is perhaps part of the same trunk, but differs from the rest in some respects. It shows considerable surface and has a good transverse fracture. No. 500.201 is a fine segment weighing 1.15 kg. and resembles the others, but there is no part missing in that trunk large enough for it to go in. It shows structure unusually well. No. 100.214 is the largest specimen of this species in the later collections and weighs 1.93 kg. It represents about half of a trunk which was compressed laterally so as to form a sharp edge. It is 16 cm. in diameter in the direction of this edge and 13 in the opposite direction across the large fracture, which is oblique to the axis. The thickness of the specimen at right angles to the plane of this fracture is 13 cm. The whole surface is covered with a thick coat of ramentum and the structure is obscure on the fractures.

Pl. LV, Fig. 1, gives a side view of No. 100.214, and Fig. 2 the rough fracture of No. 100.201. Pl. LXII, Fig. 1, shows the smooth fracture of No. 100.248.

Cycadella ferruginea Ward.

1900. *Cycadella ferruginea* Ward: Proc. Wash. Acad. Sci., Vol. I, p. 276; Twentieth Ann. Rep. U. S. Geol. Surv., 1898–99, Pt. II, p. 408, pl. cxlv–cxlvii.

Four specimens were found in the later collections that seem to belong to this species. They are all fragments, and only one, No. 500.104, merits special remark. This is upwards of half of the base of a small trunk with well-marked characters, which are those of this species. The base is perfect, and this was wanting in the type specimens. Both here and on the fractures the internal structure is clearly shown. The armor and woody zones are more clearly brought out than in the types and agree with the description in every particular. The trunk was 10 cm. in diameter and the specimen is 8 cm. high. It weighs 0.37 kg.

No. 500.192 is possibly the terminal bud of a trunk of this species. It shows the scars of the small leaves definitely and concentrically surrounding the apex of the axis, which is 7 mm. in diameter and not raised above the scars. The bud is somewhat elliptical in cross section, with a diameter of 4 cm. by 6 cm. The specimen is 5 cm. long in the direction of the axis of the bud, but none of the appendicular organs extend as far as the inner fracture, which lies in the woody zone of the trunk. The specimen weighs 0.13 kg., or, more exactly, 127 grammes. The other two specimens are very small fragments, doubtfully referred to this species.

Cycadella contracta Ward.

Pl. LVI.

1900. *Cycadella contracta* Ward: Proc. Wash. Acad. Sci., Vol. I, p. 277; Twentieth Ann. Rep. U. S. Geol. Surv., 1898–99, Pt. II, p. 409, pl. cxlviii–cliii.

The later collections considerably extend our knowledge of this species, although this is done chiefly by three specimens, and notably by one, No. 100.222, which is found to be an extension of No. 500.79, and matches what I called the upper side of the latter specimen, viz, the side opposite that shown on pl. cliii, and top of fig. 1 of pl. cli. The projection shown on the right of pl. cliii proves to be part of the base, which is entirely completed by the much thicker segment constituting No. 100.222. This overthrows my theory that Nos. 500.79 and 500.56 are parts of the same trunk. The latter shows a complete base, and now we have the complete base of another trunk, which was much larger and very anomalous in shape.

It was greatly compressed vertically, so that the axis is only about 12 cm. long, while the bulk of the material of the trunk lies in a plane perpendicular to the axis. The trunk is also compressed laterally, so that the smaller diameter is only 15 cm. In the direction of the longer diameter much is still wanting on each side. What is left measures 12 cm. The new specimen weighs 1.53 kg. and extends the original specimen 8 cm. The next most important specimen is No. 100.218, which represents more than half of a laterally compressed trunk and weighs 1.26 kg. It is smoothly broken across both ends, which seem to be the base and summit, but the axis is obscurely shown and the fractures may be somewhat oblique. It shows the external surface well on both the broader sides.

No. 100.241 is a portion of a trunk of peculiar shape, and the whole of one side is occupied by the medulla, which has a twisted appearance and shows some protuberances. The specimen is smoothly broken across the top and shows the thick armor and thin wood, covered with the coating of ramentum. Near the base this latter has disappeared and the shape of the leaf scars is shown better than in any other specimen of this species.

Pl. LVI, Fig. 1, shows the best side of the trunk No. 100.218; Pl. LVI, Fig. 2, shows the outer surface of the trunk No. 100.241, and Fig. 3 the inside on which the medulla is exposed.

Cycadella gravis Ward.

1900. *Cycadella gravis* Ward: Proc. Wash. Acad. Sci., Vol. I, p. 277; Twentieth Ann. Rep. U. S. Geol. Surv., 1898–99, Pt. II, p. 410, pl. cliv.

Only two imperfect fragments were found in the later collections that could be referred even with doubt to this species. These are Nos. 500.194 and 100.242. These most resemble the only type specimen, No. 500.63, and suggest that they may be specifically identical with it, but this is all that can be said of them.

Cycadella verrucosa Ward.

1900. *Cycadella verrucosa* Ward: Proc. Wash. Acad. Sci., Vol. I, p. 278; Twentieth Ann. Rep. U. S. Geol Surv., 1898–99, Pt. II, p. 410, pl. clv–clvii.

A single small specimen only, No. 500.505, is referred to this species, and this with grave doubt. It may represent a terminal bud, or it may only be a large branch. The surface markings point to this species and differ from those of any other.

Cycadella jejuna Ward.

Pl. LVII.

1900. *Cycadella jejuna* Ward: Proc. Wash. Acad. Sci., Vol. I, p. 279; Twentieth Ann. Rep. U. S. Geol. Surv., 1898–99, Pt. II, p. 412, pl. clviii–clxi.

A large number of fragments are referred to this species, but most of them are very small and so closely resemble one another as to suggest that a large trunk had disintegrated and been reduced to mere chips. One fragment, No. 500.101, proves to be the missing part of the type specimen No. 500.28, and completes the trunk (see pl. clviii, clix). The largest specimen is No. 500.515, and this is supplemented by another, No. 500.491. These together constitute all but a little of the summit of a trunk rather larger than the one last mentioned, but less compressed. The two pieces together weigh 2.41 kg. It is 13 cm. high and 12 cm. by 16 cm. in diameter. The base is very oblique and hollowed out on one side. The surface is well shown on all sides.

Nos. 500.103, 500.195, 500.210, 500.502, 500.504, and 500.684, all join in one way or another to form a considerable part of another trunk, but the resulting combination has no definite shape. There are besides many specimens that almost certainly belong to this trunk. Enough can thus be learned to make sure that it was a large trunk for the species and much compressed, forming a sharp edge somewhat after the manner of No. 500.64.

In the third invoice there were three small fragments that were first separately referred to this species, and afterwards found to be all complementary parts, but they show very little surface and have little value. These are Nos. 100.299, 100.317, and 100.351.

Pl. LVII is a side view of the trunk formed by Nos. 500.515 and 500.491.

Cycadella concinna Ward.

1900. *Cycadella concinna* Ward: Proc. Wash. Acad. Sci., Vol. I, p. 280; Twentieth Ann. Rep. U. S. Geol. Surv., 1898–99, Pt. II, p. 412, pl. clxii.

There were no specimens in the later collections that seemed to belong to this species. As the only specimen known (No. 500.16) is complete and presents no fractured surfaces, the nature of the internal structure is unknown, and in such fragments as constitute the bulk of the later collections this becomes the main dependence. It is, therefore, not entirely certain that this species is not represented.

Cycadella crepidaria Ward.

Pls. LVIII–LX.

1900. *Cycadella crepidaria* Ward: Proc. Wash. Acad. Sci., Vol. I, p. 280; Twentieth Ann. Rep. U. S. Geol. Surv., 1898–99, Pt. II, p. 413, pl. clxiii; pl. clxiv.

Perhaps the most important and satisfactory result of the elaboration of the additional material is that obtained for this previously little-known species. It was represented in the original collection of Mr. W. H. Reed by only one specimen, No. 500.83, which is very anomalous in form and character, and no one could tell whether these would prove constant or not if more material were to come to light. The peculiar shape, resembling a moccasin, was especially liable to vary. Neither was it probable that the size would remain constant. It was interesting, therefore, to find this species represented in the later collections. Among the fragments collected by Mr. Gilmore were four pieces, all of which bore so strikingly the characters of this species that I referred them to it before I discovered that they belonged together. In the subsequent arrangement by species these were brought into proximity, and I saw at once that they were parts of the same trunk. Two of the pieces had previously been found to fit each other and had been given the same number, No. 100.215. But one of the pieces also fits No. 100.202, and this in turn matches No. 100.230. The four pieces thus brought together form an almost complete trunk, which, though considerably larger than the type specimen previously known, has approximately the same anomalous shape, resembling a human foot. The compression, however, is more oblique, and the axis passes somewhat diagonally through the specimen. The greatest length is 28 cm., the greatest width 14 cm., and the maximum thickness 9 cm. It has a girth of about 35 cm. The four pieces together weigh 3.62 kg.

There is a still larger specimen, No. 500.506, collected by myself, which I must either refer to this species or else treat as a new species. I prefer the former course, although it requires considerable explanation of the specific characters. It is nearly circular in outline and greatly compressed vertically, so as to have a somewhat lenticular shape with rather sharp edges. The axis is slightly oblique; at least it emerges considerably on one side of the center of the upper side. This axis is 12 cm. long, which represents the greatest thickness of the specimen. The diameter is about 24 cm. and the girth 75 cm. The surface is much obscured by com-

pression and distortion, but the characters, so far as visible, are those of *C. crepidaria*. It weighs 6.13 kg.

No. 100.203 is another practically complete specimen that must be referred to this species. It is subconical in shape, much flattened laterally, and tapers from base to summit. There are no fractures and the surface characters are well shown. Even the terminal bud is present and shows the summits of the small quadrangular leaf scars. The base is also perfect, and here the axis is clearly separated from the armor all round. The two flat sides are unlike, showing that the trunk stood in an inclined position. It is 12 cm. high and the diameters of the elliptical base are 9 cm. and 16 cm., respectively, giving a girth of 39 cm. The armor varies in thickness from 5 mm. on one side to 5 cm. at the ends of the elliptical base. The axis also shows an elliptical cross section 5 cm. by 10 cm. in diameter. The trunk weighs 1.3 kg.

No. 100.226 is a somewhat larger and less perfect trunk, but conforms more nearly to the type. It is flat like that, but the base is not well shown. Most of one of the flat sides is wanting and the mold of the medulla extends from the base to near the summit in the form of a hollow trough. The other side is perfectly preserved. It is 16 cm. high and had a major diameter of 14 cm. The specimen weighs 1.67 kg.

Nos. 500.512 and 500.111, the latter quite small, exactly supplement each other to form another smaller but complete trunk. It approaches the type more closely than either of the last two specimens described, in that the axis passes through the middle, transverse to the direction of greatest extension, but differs in the fact that the flattening is lateral instead of vertical when referred to the axis. Its very irregular form can be best seen from the figures. Its height in the direction of the axis is 11 cm., and the diameters are respectively 9 cm. and 20 cm. The latter may be called the length. The girth is 45 cm. It weighs 1.91 kg. The surface is black and rough, showing the scars imperfectly. The fracture between the two specimens shows that the interior is also black and the structure obscure.

Five other small fragments have been referred to this species with more or less confidence.

Pl. LVIII is a view of the best side of the trunk consisting of Nos. 100.202, 100.215, and 100.230. Pl. LIX shows the best preserved side of No. 100.203. Pl. LX is a view of the convex side of the trunk No. 100.226.

CYCADELLA GELIDA Ward.

1900. *Cycadella gelida* Ward: Proc. Wash. Acad. Sci., Vol. I, p. 281; Twentieth Ann. Rep. U. S. Geol. Surv., 1898–99, Pt. II, p. 414, pl. clxv–clxix.

From a resemblance in the leaf scars and the general texture a number of small fragments found in the later collections are provisionally referred to this species.

CYCADELLA CARBONENSIS Ward.

1900. *Cycadella carbonensis* Ward: Proc. Wash. Acad. Sci., Vol. I, p. 282; Twentieth Ann. Rep. U. S. Geol. Surv., 1898–99, Pt. II, p. 415, pl. clxx; pl. clxxi.

In a few spots on the large type specimen, No. 500.2, the leaf scars are seen, and their great size (3 cm. wide by 15 mm. high) was one of the specific characters. Some are not more than 1 cm. high, with the maximum width. One small fragment, No. 500.376, shows scars exactly like these. The texture and color of the rock are also the same, and it is tolerably safe to refer it to this species.

CYCADELLA KNIGHTII Ward.

Pl. LXI.

1900. *Cycadella Knightii* Ward: Proc. Wash. Acad. Sci., Vol. I, p. 283, pl. xxi. Twentieth Ann. Rep. U. S. Geol. Surv., 1898–99, Pt. II, p. 416, pl. clxxii–clxxvii.

Only one specimen in the latter collection belongs with any certainty to this species, which was represented in the original collection by only two specimens, viz, Nos. 500.65 and 500.33, the former one of the largest and finest trunks found. The specimen now in question, though somewhat smaller than that, is also a large and practically complete trunk. It is the No. 500.687, collected by myself. It is much compressed laterally, deeply hollowed, and much distorted on one side. The other side is normal in shape and well preserved, but was so completely incrusted with lime that it was necessary to place it in a vat of muriatic acid for a considerable period. As this was the only side that showed the scars sufficiently well for determination, I was uncertain until the lime was removed to what species it belonged. It proves to be *C. Knightii*, and is therefore the third specimen of that species known. It is considerably smaller than the type specimen, No. 500.65, and about the size

of the less perfect specimen, No. 500.38. It is 30 cm. high, 23 cm. in longer and 14 cm. in shorter diameter, and has a girth of 58 cm. It weighs 11.34 kg.

Pl. LXI is a view of the best side (that not distorted by pressure).

INTERNAL STRUCTURE OF CYCADELLA.

In the spring of 1901 Mr. George R. Wieland, after some correspondence with Professor Knight, in which the latter authorized him to cut sections of the cycads from the Freezeout Hills, came to Washington and selected material for the purpose, which was sent to New Haven. Mr. Wieland has found time to make a somewhat careful study of some of the specimens, especially of certain ones belonging to the species *Cycadella ramantosa*, the structure of which was also studied by Doctor Knowlton and myself. The results thus far obtained are important, and at my request Mr. Wieland has kindly furnished some notes describing them and figures of the leaves detected in these fossils. I am very glad of the opportunity to introduce his notes in full in this place and also his figures.

ON THE FOLIAGE OF THE JURASSIC CYCADS OF THE GENUS CYCADELLA.

By G. R. Wieland.

One of the most gratifying results of the structural study of the fine series of silicified cycadean trunks from the Freezeout Hills of Carbon County, Wyo., constituting the genus Cycadella of Ward, has been the discovery of their young fronds. These have their structure preserved, and also exhibit their prefoliation. Although minute and yet enveloped by the surrounding armor of leaf bases and ramentum, a fact to which we are chiefly indebted for their preservation, the various tissues are already well developed, and one may surmise with no small degree of confidence what must have been the character of the fully expanded adult frond.

This is of importance because the occurrence in the fossil condition of foliage with structure preserved in connection with the trunks is rare. Of the vast numbers of isolated cycadaceous fronds with which the plant-bearing strata of Mesozoic age usually teem, wherever found upon the globe, only those of *Williamsonia gigas* (L. & H.) Carr. have been found

in organic connection with the trunks to which they belong. And even in this case the evidence upon which Williamson based his original restoration[a] was for many years called in question by most working paleobotanists.

Count Solms-Laubach (1887)[b] states that the only instance known to him of a cycad with attached leaves that could be identified with certainty was to be seen in a specimen of *Williamsonia* (*Zamites*) *gigas* from the Upper Jurassic sandstone of Yorkshire, England. This specimen was originally figured by Saporta.[c]

Still further examples of more or less full-grown fronds of the Williamsonia type, whose organic connection with stems may be proved, were given by Seward in 1897,[d] together with quite conclusive evidence in favor of the identity of Williamsonia and the cycadean trunks referred to the genus Bennettites of English and Continental paleobotanists.

Here the subject rested until I announced the discovery of the crown of young leaves with structure preserved in the type of *Cycadeoidea ingens* Ward.[e] This was one of the earliest results of the microscopic examination of our superb series of American fossil cycads undertaken by me, an examination which Professor Ward has done so much to encourage.

Since then many additional facts have been discovered concerning the leaves of the Bennettitaceæ, and the forms in various other species determined, but an account of these is reserved for a future extended publication on the entire subject. It is only intended here to describe more briefly the discovery of the leaves in a typical form of Cycadella, this making the third Bennettitean genus in which they have been positively determined, and the second in which both structure and prefoliation are known—that is, if we regard Bennettites and Cycadeoidea as including forms generically distinct. Evidence is accumulating that such is the fact.

[a] Contributions towards the History of *Zamia gigas* Lindl. & Hutt., by W. C. Williamson. Trans. Linn. Soc. London, Vol. XXVI, London, 1870, pp. 663–674, pl. lii, liii.

[b] Einleitung in die Paläophytologie, Leipzig, 1887, p. 96; Introduction to Fossil Botany, English translation, 1891, p. 94.

[c] Paléontologie française, Plantes Jurassiques, Vol. II, Paris, 1873, p. 56, pl. lxxxi, fig. 1.

[d] On the leaves of Bennettites: Proc. Cambridge Phil. Soc., Vol. IX, Pt. V, March 8, 1897, pp. 273–277.

[e] A study of some American fossil cycads; Part II, The leaf structure of cycadeoidea: Am. Journ. Sci., 4th ser., Vol. VII, April, 1899, pp. 305–308, pl. vii.

Leaves of Cycadella ramentosa Ward.—A closer examination of the middle one of the three segments figured by Professor Ward in the first paper on the Status of the Mesozoic Floras of the United States[a] possibly representing the main portion of a typical specimen of this species, resulted in the discovery of the two fronds shown in transverse section in Pl. LXII, Fig. 2, and Pl. LXIII, Fig. 1.

As is represented in the figures, both of these fronds are very small and are entirely surrounded by remarkably preserved ramentum. Both these leaves, as will be seen on examining Professor Ward's figure, showing very neatly the middle (not terminal) position of the portion of the trunk which bears them, are abnormal in being borne laterally, and not as members of a series forming a crown of leaves. They grew out, therefore, from between old leaf bases, probably after the crown of the plant had suffered some injury. As this phenomenon has been observed in some other cases not yet described, I regard it as possible that these plants may have been subject, among other mishaps, to cropping by contemporaneous animals (dinosaurs?). However, this abnormal position does not affect the orientation of these leaves. They are normal in all other respects. Their prefoliation agrees with that of *Cycadeoidea ingens*, as described by me. As in that species, they are once pinnate, the petiole being distal and the pinnules[b] folded back face to face in two ranks. But in structure there are certain points of difference. In *Cycadeoidea ingens* the hypodermal sclerenchyma beneath the upper surface of the leaf is continuous with the bundle sheath. In the present specimen there is no such connection, although the bundle sheath of sclerenchyma is strongly marked, as in the living cycad *Ceratozamia fuscoviridis* [= *C. Mexicana* Brongn.]. The prefoliation and arrangement of parts in the present fossil form bear an exceedingly close resemblance to this living form, the closest I know. But, on the other hand, *Ceratozamia terrestris*, with a strong development of hypodermal ribs of sclerenchyma on both the xylem and phloem side of the pinnule bundles is rather more like *Cordaites* (?) *anguloso-striatus* Gr. Eury., as figured by

[a] Twentieth Ann. Rep. U. S. Geol. Surv., Pt. II, 1900, pl. cxxxviii, fig. 2.

[b] These leaves are once pinnate, but since we have bipinnate cycad leaves (Bowenia), I shall use the term *pinnule* rather than *pinna*. This is the usage in some of our most recent and best publications on ferns, and the terminology of both must obviously be homological. Moreover, this is the more convenient usage, since in the case of many fossil forms the order of the laminæ is not always readily determinable.

Renault (Cour. Bot. Foss., I, pl. xii, fig. 3),[a] than like either *Cycadeoidea ingens* or *Cycadella ramantosa*. That is to say, the differences between these various forms are not such as in themselves may be very readily used for other than specific separations. The fact is also emphasized that we are here dealing with a very generalized type of leaf structure.

Bundle pattern of the petiole.—This is indicated in the young leaves of *Cycadella ramentosa* and differs markedly from that of the living cycads. It is much more fern-like in being arranged like a V with a quite continuous xylem and phloem region. It is desired to cut some further sections before giving detailed figures. In Pl. LXIII, Fig. 1, there is probably shown some distortion both of the bundle region and of the transverse section of the petiole, due perhaps to desiccation before the process of silicification began. The leaf represented in Fig. 1 of the same plate shows, in the uniform contraction between the veins of the pinnules, what is quite likely an abnormality due to the same cause. The bundle pattern of the petiole is not to be confused with that of the leaf base. The latter, of course, merges into the former.

Number of pinnules.—This has not been determined, since it has not been thought desirable to sacrifice any of these leaves by cutting them in longitudinal section, especially since number is scarcely of specific value, varying often in the case of fronds from the same plant and very greatly as a plant grows older and the relative size of its fronds increases. The number in the present species may have been as low as 30 or doubtless as high as 60.

Form of the full-grown pinnule.—This may be surmised with no small degree of confidence. The fact that in the case of the frond shown in Pl. LXIII, Fig. 1, the number of bundles increases as successive pinnules are cut, and then becomes constant, proves that the venation is dichotomous after the manner of *Zamia angustifolia* Jacq., and shows that the pinnules, though elongate, can not have had a broad base with numerous veins like Dion, nor yet like *Williamsonia gigas*. (See Pl. LXII, Figs. 1 and 4.) The degree to which the tip may have been acuminate and the relative width are of course not possible to determine from transverse sections alone. But undoubtedly the pinnules of the present species presented an appearance quite like that of such

[a] This figure is reproduced in Scott's Studies in Fossil Botany, p. 423, fig. 139A.

forms as *Podozamites lanceolatus* (L. & H.) Fr. Br. from the Jurassic of Oroville, California; *P. lanceolatus latifolius* (Fr. Br.) Heer, or *P. Emmonsii* Newb., from the Trias of North Carolina.[a]

Pl. LXII, Figs. 1–3, Pl. LXIII, Fig. 1, *Cycadella ramentosa* Ward; Pl. LXII, Fig. 4, *Williamsonia gigas* (L. & H.) Carr.

Pl. LXII, Fig. 1. Hypothetical form of portion of mature frond, based on transverse sections shown in Figs. 2 and 4. From the sections of the young fronds we learn that the frond was once pinnate and the bundle system strongly dichotomous. Further, while the exact form is somewhat conjectural the successive increase or decrease in the width of the several pinnules, as cut transversely, permits a nearly correct interpretation. (See Fig. 5, showing the best known related form.)

Pl. LXII, Fig. 2. Transverse section of a very young frond embedded in ramentum, only partly shown. The position of the petiole is shown in dotted line. The closely folded pinnules show a series of ridges corresponding to the venation and bundle system, the bundles being indicated in the drawing by small circles. The ridges are probably due to some condition attendant upon silicification. X 25. (See Pl. LXIII, Fig. 1.)

Pl. LXII, Fig. 3. Camera lucida drawing of transverse section of the ramental chaff or flattened hairs enveloping the still folded young fronds shown in Pl. LXII, Fig. 2, and Pl. LXIII, Fig. 1. These hairs were several inches in length and a single cell in thickness at their origin. Well out toward their tips they are three and four cells in thickness, as here shown. X 65.

Pl. LXIII, Fig. 1. Transverse section of an emerging young frond 1 cm. distant from that shown in Pl. LXII, Fig. 2, but larger and better preserved. The pinnules with their bundles indicated are folded back to face, in two ranks, this indicating a once pinnate frond with the prefoliation of Cycadeoidea (see Wieland, loc. cit.) and the living Dion. The somewhat furrowed (or dried?) rachis is seen at the lower right-hand corner, the interior stippled area marking the fern-like bundle system. The arrow points toward the central axis of the trunk, the rachis being distal. X 25.

[a] Professor Fontaine's figures of these forms may be consulted. They are respectively given on pl. lxiv, figs. 1 and 2, and pl. xlii, fig. 1, of the first paper on the Mesozoic Floras of the United States, Twentieth Ann. Rep. U. S. Geol. Survey, Pt. II, 1900.

Pl. LXII, Fig. 4. Seward's figure of a fine frond of *Williamsonia gigas* (L. & H.) Carr., pl. v of the Jurassic Flora of Yorkshire, Part I. Natural size, cf. Pl. LXII, Fig. 1.

Note.—Pl. LXII, Figs. 1–3, and Pl. LXIII, Fig. 1, are from the University of Wyoming cycads No. 500.39, figured on pl. cxxxviii, fig. 2, of the first paper on the Mesozoic Flora.

JURASSIC CYCADS FROM THE BLACK HILLS.

On all sides of the Black Hills the Jurassic always immediately overlies the Red Beds and underlies the Lower Cretaceous (Lakota formation of Darton). This last is the source of the great numbers of cycadean trunks that I have described from the Black Hills. These occur about midway of that formation, and below the cycad horizon are various plant beds containing impressions of cycadaceous vegetation. Until recently no plants except fossil wood had been found in the underlying Jurassic beds, the upper member of which is the Beulah formation (Beulah clays of Jenney), in which occur the Atlantosaurus beds of Marsh. When I made my fourth and last visit to the Yale Museum, in May, 1900, to complete the elaboration of the great collections of cycads that Professor Marsh had so munificently accumulated there, I found one very anomalous specimen that had been purchased for Professor Marsh by Mr. H. F. Wells from a dealer in Hot Springs who had obtained it from a stranger and had no record further than that the man who sold it to him had told him that he obtained it "50 miles west of Hot Springs in Wyoming." I named the new species, which it clearly constituted, *Cycadeoidea utopiensis*, but in the description I stated that on the surface there was "an area near the summit covered by what appears to be an outer coating of ramentum, as in the genus Cycadella, more or less obscuring the organs." At the end of the discussion I said: "The patch of ramentum, if such it be, near the summit of the specimen, raises the suspicion that it may belong to the genus Cycadella, and, as all the specimens of that genus thus far known have come from the Jurassic, it is possible that the horizon of the bed holding this specimen may be lower than that of the other Black Hills cycads." I also discussed the probable locality and regarded it as "more probable that the direction was northwest from Hot Springs,

and this might locate it in the Lakota formation some distance north of Cambria and in the general region of the Newcastle coal field."[a]

Mr. George R. Wieland, who has taken a deep interest in all matters relating to fossil cycads, whose internal structure he is so successfully working out, spent a good part of the field season of 1900 in the Black Hills making collections for the American Museum of Natural History. He paid special attention to questions of stratigraphy, and made many valuable sections, which, through the kindness of Prof. H. F. Osborn, I have the permission to use in this paper, together with other information which Mr. Wieland, at my request, has contributed. He studied the Jurassic and Lower Cretaceous beds of the Black Hills on nearly all sides, but especially on the northeast and southwest sides. In the course of his investigation of the Jurassic beds northwest of Cambria he discovered fragments of cycads in the Beulah clays, occupying a stratigraphical position similar to or identical with that of the cycad bed of the Freezeout Hills in Carbon County. This locality is between 50 and 60 miles northwest of Hot Springs, and therefore corresponds, in distance, at least, to the source of the *Cycadeoidea utopiensis*. He says that the specimens obtained there by him resemble that specimen. He has also carefully examined the patch of ramentum on that specimen described by me and has no doubt that it belongs to the genus Cycadella. There is scarcely any doubt that all this is true, that he has virtually found the locality, and that the specimen really came from Jurassic beds. The species is therefore transferred to that genus and will henceforth bear the name *Cycadella utopiensis* (Ward) Wieland. It is figured in this paper on Pl. LXIII, Fig. 2.

Mr. Wieland has furnished the following notes and sections relating to the geology and paleontology of the southwest side of the Black Hills in Crook County, Wyo., which are of special interest in this connection:

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[a] Elaboration of the fossil cycads in the Yale Museum: Am. Jour. Sci., 4th ser., Vol. X, November, 1900, pp. 327–345, pls. ii–iv. *Cycadeoidea utopiensis* is described on pp. 338–340 and figured on pl. iii, upper figure (No. 727 of the Yale Museum).

FIELD NOTES.

By G. R. Wieland.

A comparison of the beds on the southwest side of the Black Hills with those on the east and northeast sides shows that in the former the beds lie nearly horizontal and are deeply cut by streams, so that the linear exposure of the Jurassic is immensely increased. The most marked change is in the diminution of the sandstone bed beneath the main Atlantosaurus beds, or Beulah shale, if, indeed, the 25 feet of yellowish sandstone here intervening between this bed and the marine Jurassic may be considered equivalent to the "Unkpapa" of the eastern hills. And, conversely, there is an increased thickness of the overlying Beulah shales. Thickest on the northwestern side of the hills, and absent from nearly opposite Hermosa to Minnekahta, this bed, teeming at its base with the remains of huge dinosaurs, incloses the Black Hills like a long-armed crescent or horseshoe.

Most unfortunately these saurian bones are seldom well preserved and the collector is always baffled by one long stretch of talus after another. It will prove possible, however, in the course of time, to determine the extensive fauna represented, and in part its silicified flora of cycads and conifers. This being, of course, an easterly extension of the Jurassic so well marked farther west, most of the forms are doubtless already known. The section is of especial interest in connection with the stratigraphic relations of Cycadeoidea and Cycadella.

Section 4 miles west of Hulett, Crook County, Wyo.

	Feet
7. Various clays or shales and sandstones containing some silicified wood, and doubtless in their lower portions the equivalent of the Blackhawk and Minnekahta cycad beds (overlain unconformably by the Fort Benton Cretaceous)	200
6. Black shales containing more or less distinct remains of dinosaurs	50
5. Bluish shale weathering white. Contains remains of large dinosaurs, seldom well preserved, silicified wood, and probably cycads	12
4. Yellowish to red shale	8
3. Clay containing three or four thin nodular layers with remains of large dinosaurs, and ending rather sharply below as light sandy or nodular material	40
2. Sharply defined stratum of yellowish sandrock, barren, so far as observed	25
1. Marine Jurassic, ending above in limestone weathering whitish and containing remains of Baptanodon (and Megalosaurus?)	200
Total (approximate)	535

This is a much less complex section than obtains southward from Hulett in the direction of Newcastle, in which direction the Beulah shale series especially is more highly developed than elsewhere about the hills. But it is representative. That somewhere near bed No. 5 in the Beulah shales cycads are found is proved by several specimens which occur in connection with numerous remains of large saurians on the Anderson ranch, near the head of Skull Creek, 4 miles south of Inyankara Mountain. Both the fossil bones and the cycads, as well as much silicified wood, plainly belong near the base of the best marked shale seen at this point.

These cycads belong to the genus Cycadella, and are the first to be definitely located in the lower fresh-water Jurassic of the Black Hills. The fine trunk No. 727 of the Yale collection, named by Professor Ward *Cycadella utopiensis*, and originally labeled as having come from "50 miles west of Hot Springs," a very unlikely locality, doubtless came from the Inyankara Mountain country. These specimens have precisely the type of preservation seen in the Cycadellas from the Freeze-out Hills of Carbon County, Wyo. Both weather white and fracture black, with the same characteristic surface and shades, as do also the segments of silicified tree trunks not only common to both these cycad localities, but plentiful also on the eastern side of the hills. Not alone, therefore, from the general character of the Beulah shales of the eastern hills, but from the testimony of the most striking forms of animals and plants as well, must we consider them the easterly extension of the cycad horizon of the Freezeout Hills. A few feet over this horizon I believe Professor Marsh's Jurassic mammal quarries to have been located, and the cycads of the Blackhawk and Minnekahta localities in South Dakota must occur from 75 to 125 feet higher. The preservation and character of Professor Ward's *Cycadeoidea heliochorea* from 9 miles northwest of Sundance prove that it is a species belonging in the group of cycads obtained in the Minnekahta region, and that it has doubtless come from the same general position, though the specimens thus far obtained, like the great majority of the cycad trunks, were not found actually in place.

The free development of ramentum and the uniformly small size of the older or Cycadella series, as compared with the younger and larger

Cycadeoideas, is a point that at once suggests either a change in climate in the interval between the fossilization of the two groups or, if they continued to exist near each other in time, the presence about the Jurassic fresh-water lake of areas with diverse climatic conditions. In the Black Hills country, at least so far as I have noticed, there is likewise a corresponding difference in the size of the accompanying silicified tree trunks. Many of the Araucarioxylons of the upper cycad bed were of immense height and size, rivaling the Norfolk Island pines of the present, while, on the contrary, I have never found markedly large trunks in connection with the Cycadella horizon, although they may occur farther west in Wyoming. That any great change took place is not argued. The Cycadellas may have grown in dry or arid situations, or in a climate like that of Florida, where the dwarf Zamias thrive while the Cycadeoideas bespeak moister and more distinctly tropical conditions. I first pointed out, in a review in the American Journal of Science for May, 1900, page 386, the fact that Cycadella might have grown under less favorable conditions. Seward likewise considers that they may afford suggestions of value concerning climatic conditions.[a]

The microscopic study of the Cycadella series which I have undertaken in conjunction with the study of the Cycadeoidea has not been completed, so that later it will perhaps be possible to discuss such questions as this with more safety.

In connection with the relative position of Cycadeoidea and Cycadella, I should here mention that, under the direction of Professor Osborn, Dr. F. B. Loomis has prepared especially satisfactory sections of the better exposed Jurassic beds as seen farther west in Wyoming.[b] While this paper gives more exact information concerning the successive horizons and their vertebrate fossils, no mention is made of plant remains. I conclude that the bed Doctor Loomis numbers 22 is the cycad horizon of the Freezeout Hills.

NOTE ON FREMONT'S COLLECTION.

In concluding this account of the known Jurassic floras of the United States, it is well to call attention to the collection made by Fremont on

[a] See Nature, October 24, 1901, p. 633.

[b] On Jurassic stratigraphy in southeastern Wyoming: Bull. Am. Mus. Nat. Hist., Vol. XIV, Article XII, pp. 189–197.

August 19, 1843, which was elaborated by James Hall and the age pronounced Oolite by him. Part of this collection is in the National Museum, including the principal types figured by Hall, and I long ago sent it to Professor Lesquereux, who examined it and gave his reasons for agreeing with Hall, notwithstanding Heer's opinion to the contrary. Hall admitted the existence of one dicotyledonous leaf, which should have sufficed to prove his error as to age. A single glance at the leaves called *Glossopteris Phillipsii* by Hall is sufficient to show that they are dicotyledons. I have already given references to all the papers dealing with these plants,[a] but should have referred to the page of Fremont's report on which the itinerary occurs, viz, page 131. The locality is near Evanston, Wyo., and the plants probably occurred in the Bear River beds, which are certainly Cretaceous and even Upper Cretaceous, but not Laramie, as was once supposed. Dr. C. A. White and Dr. T. W. Stanton place the Bear River beds between the Dakota and Colorado formations.[b]

[a] Eighth Ann. Rep. U. S. Geol. Survey, Pt. II, 1889, p. 870.

[b] On the Bear River formation, a series of strata hitherto known as Bear River Laramie, by Charles A. White: Am. Jour. Sci., 3d ser., Vol. XLIII, February, 1892, pp. 91–97. The stratigraphic position of the Bear River formation, by T. W. Stanton: Op. cit., pp. 98–115.

PART III.

THE CRETACEOUS FLORA.

In continuation of the plan of this series as outlined in the introductory remarks to the first paper, the treatment of the Triassic flora (Part I) and the Jurassic flora (Part II) having been completed and all available information with regard to them having been brought down to date (close of the year 1903), the Cretaceous flora (Part III) may now be taken up. In endeavoring to treat the Cretaceous in strict geological sequence, beginning with the lowest, one is troubled by the fact that at least five of the Lower Cretaceous floras begin so near the base of that system that they practically constitute a transition from the Jurassic to the Cretaceous. These are the Shasta group (Knoxville beds), the Kootanie group, the Lakota group, the Trinity group, and the Older Potomac (James River beds). In view of this practical stratigraphical synchrony it becomes necessary to adopt some geographical order, and as the only Jurassic flora thus far known occurs on the Pacific slope, and especially as the Franciscan or Golden Gate formation last considered seems to form a passage bed in that region from the true Jurassic to the true Cretaceous, it seems most logical to begin with the Shasta group. It will then be most natural to work eastward and consider the Kootanie of Montana, the Lakota of the Black Hills, and the Trinity of Texas, closing with the Potomac of Virginia and Maryland.

LOWER CRETACEOUS FLORA OF QUEEN CHARLOTTE ISLANDS.

It is perhaps worth while to mention that certain beds in the Queen Charlotte Islands which have yielded fossil plants seem to occupy practically the same horizon as those mentioned above and have been correlated with both the Shasta group and the Kootanie. These beds were discovered by Mr. James Richardson in 1872 and he made extensive collections of both the fauna and the flora. His report is to be found in the

Report of Progress of the Geological Survey of Canada for the year 1872–73, page 56ff. It is followed (pp. 66–71) by a description of the fossil plants by Sir William Dawson. They consisted of coniferous wood, referred to the genera Cupressinoxylon and Taxoxylon, and one cycadaceous fruit which was named *Cycadeocarpus* (*Dioonites*) *columbianus* Dn., the last of which was illustrated by a number of magnified sections.

In 1880 Dr. G. M. Dawson published an elaborate report on the Geology of the Queen Charlotte Islands.[a] Considerable collections of fossil plants had been made at that date and continued to be made thereafter. In 1902 Prof. D. P. Penhallow[b] described and figured in great detail a fossil fern, *Osmundites skidegatensis* Penh. n. sp., collected by Dr. C. F. Newcombe on Skidegate Inlet, Alliford Bay, Queen Charlotte Islands, and in the same volume[c] he published a somewhat full account of the fossil-plant material brought together by Sir William Dawson, including the following species from the Queen Charlotte Islands:

Osmundites skidegatensis Penh.
Neuropteris heterophylla Brongn.
Tæniopteris plumosa Dn.
Sagenopteris Nilsoniana (Brongn.) Ward.
Sagenopteris oblongifolia Penh. n. sp.
Sagenopteris elliptica Font.
Zamites crassinervis Font.
Zamites tenuinervis Font.
Nilsonia polymorpha cretacea Penh. n. var.
Ginkgo pusilla Dn.
Sequoia Langsdorfii (Brongn.) Heer.

His only figures are of internal structure, which does not usually give specific characters, and only three of the species are even thus illustrated. Some of the names are prima facie doubtful, e. g., *Neuropteris heterophylla* and *Sagenopteris Nilsoniana*, the first a Carboniferous species, and the other Older Mesozoic. These at least should be figured, that one may judge better of the age of the formation. His *Nilsonia polymorpha cretacea*, which he calls a new combination, but which seems to be a new variety of his own, is also doubtful. He cites the figure in Schimper's Atlas, pl. xlv, fig. 6 (copied from Schenk's Flora d. Grenzschichten, pl. xxix, fig. 11), from the Rhetic of Franconia. If he has such a leaf it is strong evidence of at least Jurassic age.

[a] Geological Survey of Canada, Report of Progress for 1878–79, Montreal, 1880, pp. 1–239B.
[b] Trans. Roy. Soc. Canada, Sect. IV, Vol. VIII, pp. 3–29, pl. i–vi (=pp. 19–29).
[c] Pages 31–91, pl. vii–xvi (=pp. 73–91).

FLORA OF THE SHASTA FORMATION.

Fossil plants have been found in the Shasta beds in both California and Oregon. Until recently there was great confusion in the plant-bearing beds of Oregon, as it was not supposed that the Jurassic was found there. As shown in this paper, however, all the specimens from the Buck Mountain region, as well as those from the Cow Creek Valley, near Nichols station, came from the Jurassic. Those, however, from localities farther east, especially from near the town of Riddles, are of Shasta age and will be treated under this head.

During the progress of the topographic survey of the Red Bluff quadrangle, in Shasta and Tehama counties, Cal., in charge of Mr. Gilbert Thompson, which was made in the years 1882–1884, Mr. Thompson found a plant-bearing bed near Pettyjohn's ranch, on the Cold Fork of Cottonwood Creek, Tehama County, and collected and sent in a number of specimens. Only one of these, however, seems to have been saved, and this was sent to Prof. Leo Lesquereux, who determined it as a Pecopteris, without assigning to it a specific name. As such it was duly recorded in the catalogue of the National Museum as No. 2193. It was in two parts, completing each other, and these have been glued together. These parts bear Professor Lesquereux's numbers 254 and 255. Owing to the obscure chirography of the label, the name of the locality was misspelled in the Catalogue and the attention of the geologists who subsequently studied the beds of this region was not called to it. As soon as the correct name, Pettyjohn's ranch, was known, the specimen, which had long lain in a drawer waiting for data to fix its position in the collections, assumed a special interest and steps were taken to learn more of its history. It was shown to Mr. Gilbert Thompson, who recognized it at once and distinctly remembered collecting it. He indicated the exact locality on the map, which would certainly place it in the Shasta formation and well up in the Horsetown beds near the base of the Chico. The character of the rock agrees well with this and there is nothing remarkable except the fact that the plant seems to represent the chiefly Paleozoic genus Pecopteris. It is a large, distinct fern, wholly unlike any of the others that were collected in that region. It may well have been a tree fern. As Professor Fontaine says, the finer nervation is not shown, and it is still possible that it may belong to some of the Mesozoic genera to which

many of the ferns of that age, first regarded as belonging to Pecopteris, have recently been referred.

In the spring of 1887 Dr. C. A. White showed me a specimen from the Shasta formation of California that had come into his possession without any more definite indication of its exact source. I sent the specimen, on April 4, to Professor Fontaine, who replied: "The specimen * * * is a Sagenopteris. I can not distinguish it from *Sagenopteris elliptica* sp. nov., the most abundant species found in the Lower Potomac group of Virginia."

This species, as will be seen, occurred in later collections, but is not very common.

The next earliest record we have of the discovery of fossil plants in the Shasta formation is that of a few specimens turned over to the division of paleobotany of the United States Geological Survey by Dr. T. W. Stanton on March 17, 1890. They appear to have been collected the previous season by Mr. Will Q. Brown, and were found in the Horsetown beds, in the vicinity of Riddles, Oreg. Two other specimens were received in February, 1892, from Mr. J. S. Diller, collected also by Mr. Brown, in 1891, from the same locality, viz, "on Cow Creek, close to the town of Riddles." Mr. Diller sent two other specimens direct from the field in June, 1892, also from near Riddles.

In 1893 Doctor Stanton and Mr. Diller, assisted by Mr. James Storrs, made extensive collections from the Knoxville and Horsetown beds of California on the eastern slopes of the Coast Range, drainage of the Sacramento River, below the latitude of Mount Shasta. They found an abundant fauna, but the flora was meager. Still, their collections of fossil plants were rather large and came into my hands before the end of that year. I made a preliminary report upon them, but was obliged, for want of time, to send them to Prof. Wm. M. Fontaine for more thorough examination. He reported upon them somewhat fully under date of February 23, 1894, and his identifications were published by Diller and Stanton in their paper read before the Geological Society of America, which, though read on December 27, 1893, or before the report was completed, was not published until April 12, 1894.[a]

[a] The Shasta-Chico series, by J. S. Diller and T. W. Stanton: Bull. Geol. Soc. America, Vol. V, Rochester, April, 1894, pp. 435–464. See pp. 450, 451.

In 1894 Doctor Stanton collected two specimens in the vicinity of Riddles, on the left bank of Cow Creek, which was practically the same locality as that of most of Mr. Brown's collections, though a few came from the low ridge a mile or more southeast of the town and some distance from the river. These also were sent to Professor Fontaine, who reported on them to Doctor Stanton under date of March 12, 1895, and the identifications were published soon after.[a]

The fragmentary character of the material from all these beds, which rendered most of the determinations more or less doubtful, made it desirable to have a more special search made for vegetable remains, and at the urgent request of Mr. Diller I decided to spend some time in California with this object in view. I secured as accurate information respecting the localities as possible and joined Mr. Diller's party at Roseburg, Oreg., on September 6, 1895, after having made the collection of Kootanie plants at Great Falls, Mont., to be described later. It was arranged that Mr. Storrs should accompany me to the localities in California. I did not stop at Riddles, as the importance of the fossil flora of that region had not yet been emphasized, but proceeded to Ono, Shasta County, Cal., where Mr. Storrs soon joined me, and we spent sixteen days in the general region where fossil plants had been previously obtained.

Ono was made the base of operations from September 9 to September 15, and the principal localities in that vicinity were very carefully examined. Fossil plants were found in Byron Gulch, northwest of Ono and close to the town; on Cottonwood Creek, below the mouth of Eagle Creek and above that of Hulen Creek; southeast of Ono; and in Aldersons Gulch, 2 miles southwest of Ono. We also spent a day in the vicinity of Horsetown, which is 8 miles east-northeast from Ono.

Two miles northeast of Horsetown, on the road to Centerville, at the southern base of a nearly east-west ridge, the Cretaceous is exposed, overlain by a mass of tufa. In the fine-grained concretionary rocks that occur among the shales, much as they do in the region around Ono, we made a fairly good collection of plants, mostly conifers.

The localities near Ono yielded comparatively little. A few fern fragments were found in Byron Gulch. Coal was reported on Cotton-

[a] Contributions to the Cretaceous paleontology of the Pacific coast; the fauna of the Knoxville beds, by T. W. Stanton: Bull. U. S. Geol. Survey No. 133, 1895 (issued February 3, 1896). See p. 22.

wood Creek, and a man who had seen it guided us to the locality, which is on Cottonwood Creek, a quarter of a mile below the mouth of Eagle Creek. As I expected, the coal proved to be lignite, and there are many lignitized as well as silicified logs and quantities of blocks of fossil wood. The trunks are frequently silicified in the center and lignitized near the surface. The wood usually shows the grain well. Many of the rocks in which the trunks are embedded contain vegetable matter, mostly in the form of coaly stems. A few recognizable plant impressions were, however, found, chiefly fragments of ferns and leaf-bearing coniferous twigs.

As the strike of these beds is here northeast-southwest and the dip to the southeast is very steep even here, though much less so than farther south, the strata rise rapidly in descending Cottonwood Creek, and there is a correspondingly rapid change in the character of the flora. The strata could not be traced continuously, but at the mouth of Hulen Creek, 100 yards above the junction of the two streams, in coarse, dark-colored sandstone shales, dicotyledonous leaves were found. Owing to the coarse matrix, the nervation is obscure and the material obtained is rather poor. This bed belongs to the Chico, according to Doctor Stanton's determinations, and these dicotyledonous leaves are not included in the descriptions given in this paper, but the material is reserved for a later paper which will treat exclusively of the upper leaf-bearing beds of the Lower Cretaceous.

In Aldersons Gulch plants were exceedingly scarce, but in two places we found them in the hard, fine-grained concretionary rocks that everywhere form seams among the shales. Several coniferous twigs were found, a few showing the leaves. Cycadaceous vegetation was also detected. Fossil wood is abundant.

On the 16th we left Ono and proceeded southward to Stephenson's ranch, on the Cold Fork of Cottonwood Creek, a mile above Pettyjohn's, in Tehama County. A few fossil plants were found on this stream at two localities above the ranch, chiefly ferns and conifers. Vegetable remains are here very rare.

From here we continued our journey southward and arrived on the 18th at Lowry, on Elder Creek, which was made the base of operations during the remainder of the expedition. Four miles west of Lowry, on the North Fork of Elder Creek, plant remains were found at several

localities and horizons, but usually in very small fragments, consisting of the tips of the pinnules of ferns, cycads, etc. On the South Fork of Elder Creek, from 1½ to 2 miles above Lowry, at and below the dam, plants also occur in much the same condition as at the last-mentioned localities. Farther up the South Fork, below Coopers, 5 miles southwest of Lowrys, near the gorge where the South Fork cuts through a heavy bed of conglomerate, we found a bed that yielded ferns, cycadaceous leaves, etc., and made a considerable collection.

The most southern point visited was Wilcox's ranch, 6 miles south of Lowry, and over the divide between Elder Creek and Thome Creek, on the road to Paskenta. Mr. Storrs had found one specimen here on a former occasion, but we were unable to find any more at the original locality. At another place, half a mile east of Wilcox's, we found some very imperfect fragments. Just on the crest of the divide, about midway between Lowry and Wilcox's, a bed was discovered by the roadside containing delicate fern impressions and detached cycadaceous leaflets. They occur in a rather fine sandstone shale, slightly concretionary, and were found on both sides of the road, but chiefly on the east side, at two horizons 30 feet apart. A large number of specimens were obtained.

A single dicotyledonous leaf had been collected by Doctor Stanton in 1893 from a locality 2½ miles below, or to the east of Lowry, on Elder Creek, and Mr. Storrs and I tried to find the spot, but probably failed. At least we found no fossil plants in that general region. Half a mile above, however, on the left bank of Elder Creek, a few fragments were broken out of a coarse sandstone ledge, one of which was a small fern, and the rest seemed to be pine needles. A much better locality, and one that had not been previously discovered, was at the eroded end of a low ridge running north from Elder Creek, only half a mile below Lowry. In a light-brown sandstone ledge at this point there occur well-preserved dicotyledonous leaves and some other vegetable impressions, of which we made a considerable collection. As in the case of the dicotyledons found at the mouth of Hulen Creek, these leaves are reserved for a future paper.

The last-named locality belongs to the upper Horsetown beds according to the sections that have been made, but the specimen collected by Doctor Stanton 2 miles below comes well up in the Chico. It was on

Elder Creek that Mr. Diller made his well-known section,[a] which so staggered the geologists who are studying the age of the earth. According to this section the Knoxville beds have a thickness on Elder Creek of 20,000 feet, the Horsetown beds of about 6,000 feet, and the Chico beds of 4,000 feet, making 30,000 feet measured. And yet it seems that "the complete series of the Shasta-Chico beds is not exposed in this section."[b] The strata here often approach a vertical position and the section stretches across their upturned edges for a distance of nearly 8 miles. They consist of shales, sandstones, and conglomerates with calcareous bands in the Knoxville beds. There are no indications of the existence of heavy deposits of eruptive material or other forms of rapid deposition, and the faulting and folding is slight and local. Doctor Stanton, who has made later and more special examinations, thinks, however, that certain facts observed by him may ultimately somewhat modify these extreme results. There can be no doubt that these beds embrace practically the whole of the Lower Cretaceous, and Doctor Stanton would place the Chico beds in the Upper Cretaceous,with their lower portion on about the horizon of the Cenomanian.

These collections reached Washington in the autumn of 1895. I made a preliminary study of them during the winter, comparing them carefully with those previously received from substantially the same localities. In many cases they proved much fuller and greatly increased our knowledge of the flora of those beds, but in others, as already stated, Mr. Storrs and I were unable to find any additional material, and in still others what we obtained was inferior in quantity and quality to that previously collected.

Professor Fontaine was at that time engaged on other work and could not undertake the determination of these collections. I had planned the series of papers now in progress and, as stated in the first paper, deemed it important to begin with the lowest Mesozoic floras and work up to those of the Lower Cretaceous. This plan has been adhered to, although it necessitated the postponement of the determination of collections made earlier than some that have been published. The history of this work has all been fully given in its proper place.

[a] Am. Jour. Sci., 3d ser., Vol. XL, December, 1890, p. 476; Bull. Geol. Soc. America, Vol. V, 1894, pp. 439–440.

[b] Bull. Geol. Soc. America, Vol. V, 1894, p. 438 (footnote).

No time, however, was lost in having the Cretaceous plants determined, and in July, 1897, all the collections thus far made from the Shasta beds, including those that had already been once studied and reported upon, were sent to Professor Fontaine and he made a thorough examination of it all in the light of the latest collections. His final report was completed and transmitted on February 21, 1898, and the collections were returned to Washington. Owing to the necessity of having the Jurassic floras illustrated first, I did not send the types of the Shasta flora to the division of illustrations till near the end of May, 1899. They were promptly taken up and completed in July.

During this time a few small collections of Horsetown plants had been made from several localities in Oregon. A single specimen was obtained by Mr. Diller from Mr. Claude Rice, who gave the locality as 25 miles a little south of east of Buck Mountain. It consisted of a small dicotyledonous leaf on a rock containing shells of Horsetown age, and was first sent to Doctor Stanton, who turned it over to me on April 25, 1898. Three other specimens came into my hands through Mr. Diller on May 31, 1898. One of them, in two complementary parts, was collected by Mr. Rice, but the precise locality is not stated. The other two, one of which was also in two complementary parts, were collected by Mr. Brown on Cow Creek at Riddles. Another specimen, also collected by Mr. Brown, but from a different locality, viz, on Iron Mountain Creek, half a mile above its junction with Cow Creek, was sent me on February 9, 1899. This locality is in the Knoxville beds and is only about 3 miles below Nichols station, where the collection of Jurassic plants was made. I visited it in company with Mr. Brown on September 18, 1899, but we could no find more plant impressions. Aucella is very abundant in the same rocks that yielded the plant. On September 21–23, 1899, I visited several of the localities near Riddles where Mr. Brown had found fossil plants in the shell-bearing shales of the Horsetown beds, but I was mainly unsuccessful in finding plants, which are very rare.

The interest aroused by bringing to light the specimen collected near Pettyjohn's ranch by Mr. Gilbert Thompson in 1882 led to a renewed effort to rediscover the locality. Mr. Thompson furnished Doctor Stanton with full details, including a sketch map of the region, and on September 15 and 16, 1892, the latter visited the place and made a very careful examination of the beds. He collected specimens showing

obscure vegetable impressions at five points, designated on his labels as follows in their relation to Pettyjohn's ranch: 1, about 3 miles a little west of north; 2, about 3¼ miles a little west of north; 3, 2 miles below (southeast?); 4, 1½ miles north; 5, 1½ miles northeast. Nos. 3 and 4 are on the Cold Fork of Cottonwood Creek, No. 4 being in the canyon; No. 5 is on the trail. None of the specimens bear any close resemblance to that obtained by Mr. Thompson, and the presumption is that the exact locality was not found.

These specimens were sent to Professor Fontaine on February 16, 1903, and his report upon them was received on March 10. It is as follows:

I have carefully examined the fossil plants collected by Dr. Stanton from the vicinity of Pettyjohn's ranch, Tehama County, Cal. The collections unfortunately show nothing that can be positively determined. Most of the specimens can not be even generically determined. Many of them are vague imprints of stems or small scraps of leaves with none of the original form preserved. The best specimens do not show enough to give any idea of the true character of the plants. The following are the collections now in question:

Collection No. 1, as designated above.—This was obtained from a locality about 3 miles a little west of north from Pettyjohn's ranch. It contains 6 specimens, none of which are even approximately determinable. The most that can be made out is that they are fragments of plants.

Collection No. 2.—This comes from about 3¼ miles northwest of Pettyjohn's ranch, several hundred feet above No. 1. . It has only 3 specimens. Only 1 of these can be even approximately determined. It is the basal portion of a dicotyledonous leaf that resembles *Celastrophyllum brookense* Font., from the Aquia Creek beds of the Lower Potomac of Virginia. It resembles also *Ficus atavina* Heer, from the Atane beds of Greenland. There is not enough of the fossil to determine its true character.

Collection No. 3.—This collection has 12 specimens. None of these seem to be dicotyledons. The fossils come from the Cold Fork of Cottonwood Creek, about 2 miles below Pettyjohn's ranch. Seven of the specimens show only vague scraps of plants. Five of them have each a small portion of an ultimate pinna of some fern that shows only a few poorly preserved pinnules of the type of *Thyrsopteris rarinervis* Font. or *Asplenium Dicksonianum* Heer. They all apparently belong to the same species. It may be either of the two forms mentioned above, for the material does not suffice to determine the question. The former of these occurs in the Lower Potomac and the latter ranges from the Kome strata of Greenland to the Atane of the same region.

Collection No. 4.—This comes from the canyon of the Cold Fork of Cottonwood Creek, 1½ miles north of Pettyjohn's ranch. It is the largest of the collections and

contains 36 specimens. Nineteen of them show nothing that can be even approximately determined. Most of these have vague imprints of stems. The remaining specimens contain fragments of leaves that give some hint of their character, but none of them can be positively determined.

1. A fragment of a rather large leaf, showing no principal nerve. The nervation, which is poorly preserved, is all equally strong and shows an anastomosis that may be either that of Sagenopteris or Proteæphyllum. It looks more like a Proteæphyllum.

2. Four of the specimens have each a small fragment of an ultimate pinna of some fern. They may be of the same species, but the pinnules of one are longer and proportionally narrower than those of the others. No nervation is shown and the preservation is too imperfect to admit of even generic determination. They look like Gleichenia, or a small Dicksonia. *Gleichenia gracilis* Heer is not unlike these fossils. This Gleichenia is found in both the Kome and the Atane beds of Greenland.

3. Four specimens contain each a small fragment of the ultimate pinna of the type of *Thyrsopteris rarinervis* or *Asplenium Dicksonianum* Heer. They are too poorly preserved to make out their true character.

4. Three of the specimens show each a small fragment of the ultimate pinna of a fern that has the appearance of a small Cladophlebis. None of them show more than a few poorly preserved pinnules. They agree pretty well with *Pteris Albertsii* (Dunk.) Heer of the Atane beds of Greenland, but may equally as well be one of the Cladophlebis of the Lower Potomac.

5. One specimen contains a fragment of a detached leaf that, in form and size, agrees well with *Nageiopsis longifolia* Font. of the Lower Potomac. As, however, the base, tip, and nervation are not shown, it is impossible to determine its character.

6. Another specimen shows a similarly imperfect fragment of what may be *Nageiopsis heterophylla* Font. At least it is a smaller leaf of the same type as the one last mentioned.

7. Still another fragment of the same type of leaf agrees best with *Nageiopsis angustifolia* Font. None of these suffice to give more than hints.

8. One specimen shows a fragment, about 15 mm. wide, of a larger leaf of the same general character as the preceding. It may be a large Nageiopsis or Podozamites. Its shape and size are not shown. The nerves are parallel, unbranched, strong, and apparently double.

9. One specimen shows three detached rigid leaves of some conifer that agrees well with *Sequoia rigida* Heer of the Greenland Atane beds. The fragments, however, are not sufficient to permit identification with that plant.

10. Another fragment may be a Nilsonia or Tæniopteris. It has neither base nor tip. A pretty strong midrib is present. The lateral nerves are obscure, but seem to be those of one or the other of these two genera.

If the plant described first is not a Proteæphyllum, this collection has no dicotyledon.

Collection No. 5.—These come from the trail, about 1½ miles northeast of Pettyjohn's ranch. The collection contains 22 specimens. Six of them show scraps of detached pinnules of a large fern of Cladophlebis type. Only one of these shows a nearly complete pinnule, and much more and better material is needed to determine the plant, for it is of a type that ranges from the Jurassic to the Upper Cretaceous. The margins of this pinnule are finely denticulate and it may be *Pteris frigida* Heer, from the Atane beds of Greenland.

There are two specimens that contain each a small fragment of an ultimate pinna with a few poorly preserved pinnules that may be *Gleichenia gracilis* Heer, or a small Dicksonia. Two specimens contain, one each, a fragment of an ultimate pinna of a fern of Cladophlebis type smaller than the possible *Pteris frigida* Heer. A number of species of this type also range from the Jurassic to the Upper Cretaceous, and the material is not sufficient to determine the true place of this plant. It may very well be a small form of *Dryopteris Oerstedi* (Heer) Kn., or *Pteris Albertsii* (Dunk.) Heer, both found by Heer in the Atane beds of Greenland.

There are on three rock specimens small fragments of a leaf with anastomosing nervation. The leaf is a small one and resembles a Sagenopteris. It may be a new species.

Several specimens show scraps that are apparently leaves of some dicotyledon, but they are not sufficient to indicate even generic position. There is one fragment, and one nearly complete leaf, of a dicotyledon that strongly resembles *Sapindopsis parvifolia* Font., a plant confined to the Aquia Creek horizon of the Lower Potomac. There are also two fragments, on different rock fragments, of a dicotyledon that was of larger size than the one last described. This looks like a Sapindopsis, but the specimens are too incomplete to give a hint as to what species it may be.

One fragment has the shape and size of *Nageiopsis longifolia*. It is a detached leaf showing neither base nor tip, and no nerves; hence it is not possible to determine it.

This collection has a larger number of dicotyledons than any of the others. Collection No. 1 has nothing determinable, and hence the plants give no hint of the age of the strata containing them. Collection No. 2 is entirely too small to be of value for determining age, even if all three specimens could be determined. The only determinable plant is a dicotyledon of rather modern aspect. So far as it goes, it indicates an age not greater than the Aquia Creek stage of the Lower Potomac. It, however, may be of the age of the Atane or Upper Cretaceous of Greenland. Collection No. 3 has no dicotyledons, and if we look to these alone, this would indicate that the formation yielding it is somewhat older than that of collections Nos. 2 and 5. From only 12 specimens, however, it would be unsafe to draw negative conclusions. The age of this may be either Lower Potomac or Atane. Collection No. 4 is remarkably free from dicotyledons, and as this is the largest their absence has more significance. It taken alone would indicate an age somewhat greater than that of collections Nos. 2 and 5. The plants indicate a Cretaceous age, but do not decide between the Lower Potomac and Atane, to either of which they may belong. The

fossils contained in collection No. 5 indicate that the formation containing them is not older than the Aquia Creek stage of the Lower Potomac. They may be as young as the Atane strata.

All the other collections were sent to Professor Fontaine much earlier and his determinations are embodied in the descriptions of the species given below.

The accompanying sketch map (Pl. LXIV) of the general region in California where collections of Shasta plants were made will assist the reader in locating the beds geographically in that State. For those in Oregon, see Pl. V.

NOTES ON SOME FOSSIL PLANTS FROM THE SHASTA GROUP OF CALIFORNIA AND OREGON.

By William M. Fontaine.

The object of this paper is chiefly to give the result of the examination of three parcels of fossil plants collected from the Shasta group of California and Oregon.

One of the parcels contains fossils collected by Messrs. Diller, Stanton, and Storrs, in 1893 and 1894, from the following localities in California. The numbering is my own, and is intended simply to make reference easy.

Locality No. 1.[a]—One and one-half miles northeast of Horsetown, Shasta County, Cal. Typical Horsetown beds. Collected by T. W. Stanton, 1893.

Locality No. 2.—North Fork of Cottonwood Creek, below the mouth of Eagle Creek, Shasta County, Cal. Horsetown beds. Collected by T. W. Stanton, 1893.

Locality No. 3.—Eagle Creek, near Ono, Shasta County, Cal. Lower part of Horsetown beds. Collected by T. W. Stanton, 1893.

Locality No. 4.—Byron Gulch, near Ono, Shasta County, Cal. Horsetown beds, slightly higher than No. 5. Collected by T. W. Stanton, 1893.

Locality No. 5.—Byron Gulch, near Ono, Shasta County, Cal. The lowest fossiliferous horizon of the section. Base of the Horsetown beds. Collected by T. W. Stanton, 1893.

Locality No. 6.—Aldersons Gulch, 2 miles south of Ono, Shasta County, Cal. Lower part of Horsetown beds. Collected by T. W. Stanton, 1893.

Locality No. 7.—Cold Fork of Cottonwood Creek, Tehama County, Cal. Upper Knoxville (Aucella) beds. Collected by T. W. Stanton, 1893.

Locality No. 8.—Elder Creek, 2½ miles below Lowry, Tehama County, Cal. Base of the Chico group. Collected by T. W. Stanton, 1893.

Locality No. 9.—Elder Creek section, 3¾ miles above Lowry, Tehama County, Cal. Knoxville beds. Collected by Stanton and Storrs, 1893.

[a] The numbers on the map (Pl. LXIV) correspond to those given in the text.

Locality No. 10.—South Fork of Elder Creek, near Coopers, and 5 miles southwest of Lowry, Tehama County, Cal. Knoxville beds. Collected by T. W. Stanton, 1893.

Locality No. 11.—South Fork of Elder Creek, near the schoolhouse, about a mile south and a little west of Lowry, Tehama County, Cal. Knoxville beds. Collected by Diller, Stanton, and Storrs, 1893.

Locality No. 12.—One-half mile east of Wilcox's and 4 miles south of Lowry, Tehama County, Cal. Uppermost Knoxville (Aucella) beds. Collected by T. W. Stanton, 1893.

Locality No. 13.—Five-eighths of a mile northeast of Wilcox's and 4 miles south of Lowry, Tehama County, Cal. Base of Horsetown beds, and about 150 feet above locality No. 12. Collected by T. W. Stanton, 1893.

Locality No. 14.—McCarty Creek, about 2 miles north of Paskenta, Tehama County, Cal. Knoxville beds. Probably 1,000 feet or more below their top. Collected by T. W. Stanton, 1893.

Although the number of localities from which these plants were collected is considerable, the amount of material showing plant fossils that can be identified is small and the impressions are very fragmentary and obscure. This is to be expected, as the beds containing them are marine and show the remains of marine mollusks, such as Aucella, etc. They were probably deposits laid down at some distance from the land and plants contained in them must have drifted far and suffered much. The recognizable impressions fill only a small box.

In the fall of 1895 Prof. Lester F. Ward visited the region in which these localities occur, with the hope that persistent search would disclose better specimens. He was aided by Mr. Storrs, and under his guidance was enabled to make additional collections from some of the localities named in the preceding list. In some cases, where the exact locality was not certainly identified, collections were made from nearly the same spot. Two new localities were found. Messrs. Ward and Storrs collected from localities Nos. 1, 4, 9, and 14 of the Stanton-Diller list, and from the following that were not certainly identified as the same with those of that list. These I will, for convenience of reference, number consecutively with the Stanton-Diller list. The descriptions are those given by Professor Ward.

Locality No. 15.—Near the same locality as No. 4, only farther up Byron Gulch, above the cascade, probably about the same as No. 5.

Locality No. 16.—One-fourth of a mile below the mouth of Eagle Creek, left bank of the North Fork of Cottonwood Creek, near Ono, Shasta County, Cal. Probably nearly the same as No. 2.

Locality No. 17.—Aldersons Gulch, 2 miles southwest of Ono, Shasta County, Cal. Probably about the same as No. 6.

Locality No. 18.—Cold Fork of Cottonwood Creek, in the first gulch above Stephenson's ranch, Tehama County, Cal. About the same as No. 7.

Locality No. 19.—South Fork of Elder Creek, 1½ miles south of Lowry, Tehama County, Cal. Nearly the same as locality No. 11.

Locality No. 20.—South Fork of Elder Creek, 5 miles southwest of Lowry, and one-fourth of a mile below Coopers, near the conglomerate gorge, Tehama County, Cal. This is near locality No. 10.

Locality No. 21.—Elder Creek, 2½ miles below Lowry, and one-half mile below the Gallatin ranch, Tehama County, Cal. This is near locality No. 8, and at the base of the Chico formation.

The following are the new localities:

Locality No. 22.—Divide between Elder Creek and Thome Creek, in the road from Lowry to Paskenta, Tehama County, Cal. Knoxville beds.

Locality No. 23.—Elder Creek, one-half mile, or a little less, below (east of) Lowry, Tehama County, Cal. Probably top of Horsetown beds.

The collection is larger than that made by Messrs. Stanton, Diller, and Storrs, but does not add many new species. The impressions, like those of Messrs. Stanton and Diller, are very fragmentary and poorly preserved, so that it is very difficult to make satisfactory determinations. This is especially true of some of the ferns. Many of these are represented by small fragments, and in a number of cases these bits may belong to any one of several species.

The third parcel contains six specimens collected by Messrs. T. W. Stanton and Will Q. Brown, in 1890, near Riddles, Oreg., from strata in Cow Creek Valley that are, in Mr. Diller's opinion, probably of Horsetown age.

These specimens are much better preserved than most of those from the California localities. They indicate that the plants furnishing them grew on some spot near where they are now found, so that they did not float far before they were buried in sediment.[a]

[a] Besides these principal collections these notes include the descriptions of the several scattered specimens from the Shasta formation in Oregon and California that have come in since the large collections were made, and which have been noted in the historical part of this paper (see pp. 211, 217). The localities are there fully given and will be recognized without being numbered.

I have included in the synonymy of the species described in this report all the names that had previously been published by Mr. Diller and Doctor Stanton (see pp. 212, 213), whether subsequently changed by Professor Fontaine or not. They will thus be easily identified.—L. F. W.

DESCRIPTION OF THE SPECIES.

Phylum PTERIDOPHYTA (Ferns and Fern Allies).

Order FILICALES (Ferns).

Family CYATHEACEÆ.

Genus DICKSONIA L'Héritier.

DICKSONIA PACHYPHYLLA Fontaine n. sp.

Pl. LXV, Fig. 1.

1894. *Aspleniopteris pinnatifida* Font.? in Diller & Stanton: Bull. Geol. Soc. Am., Vol. V, p. 450.

1895 [1896]. *Aspleniopteris pinnatifida* Font.? in Stanton: Bull. U. S. Geol. Surv., No. 133, p. 15.

A single imprint of a fern in fruit was found at locality No. 9. It shows the terminal portion of what appears to have been an ultimate pinna. The amount of material is too small to permit its positive determination. It is, however, much like a plant from Cascade County, Mont. Professor Ward and Mr. Weed recently made a considerable collection of fossil plants in Cascade County, Mont., a few miles from the town of Geyser. These fossils appear to occur in the same system of beds as those yielding the fossils of Great Falls. They are of Lower Cretaceous age, belonging to the Kootanie or Lower Potomac phase of that flora. For the sake of description I have named the strata yielding these Cascade plants the Geyser beds. The description of these plants is published in this paper.

Among the plants from the Geyser beds two small bits of a fruiting fern were found. They apparently belong to a new species of Dicksonia, but as the amount of material is very small and the specimens are very imperfect, I did not venture to do more than describe it as a doubtful new species, giving it, for the sake of reference, the name *Dicksonia pachyphylla*. The plant now in question, from the Shasta beds, is much like the Geyser fossil, and my sole reason for doubtfully identifying it with that

[a] It happened in the progress of the work that the collections from the Kootanie of Great Falls, Mont., were sent to Professor Fontaine before those from the Shasta formation were ready, and he reported on them first.—L. F. W.

plant is the scantiness and imperfection of the material. It may be described as follows: Frond unknown, sterile form not certainly known. Only portions of the ultimate fertile pinnæ or pinnules have been found. Pinnules or lobes in the fruiting forms, almost or quite reduced to short thickened nerves, which bear at their ends large globose or subreniform sori. The leaf substance is very thick and durable, so that the plant leaves a thick film of carbonaceous matter on the rock.

Genus THYRSOPTERIS Kuntze.

THYRSOPTERIS RARINERVIS Fontaine?

Pl. LXV, Figs. 2–4.

1889. *Thyrsopteris rarinervis* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 123, pl. xxvi, figs. 6, 7; pl. xliii, figs. 4, 4a, 6, 6a; pl. xliv, figs. 1, 1a, 2, 5, 5a; pl. xlix, figs. 2, 2a, 2b; pl. clxix, figs. 6, 7.

1894. *Thyrsopteris rarinervis* Font.? in Diller & Stanton: Bull. Geol. Soc. Am., Vol. V, p. 450. (Pl. LXV, Figs. 3, 4).

1895 [1896]. *Thyrsopteris rarinervis* Font.? in Stanton: Bull. U. S. Geol. Surv., No. 133, p. 15. (Pl. LXV, Figs. 3, 4).

Several specimens of what seems to be the widely diffused fern *Thyrsopteris rarinervis* were found. They were obtained at localities Nos. 9 and 18. They consist of small portions of penultimate pinnæ, carrying pinnules not distinguishable from those of *T. rarinervis* Font., which was first found in the Lower Potomac of Virginia, in which it is one of the most common ferns. It has since been found in most of the regions of the United States that yield plants of Lower Cretaceous age. The amount of material is not sufficient to justify a positive determination of this plant as *Thyrsopteris rarinervis*, and for this reason it is marked as doubtful.

Family POLYPODIACEÆ.

Genus CLADOPHLEBIS Brongniart.

CLADOPHLEBIS PARVA Fontaine.

Pl. LXV, Figs. 5–8.

1889. *Cladophlebis parva* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 73, pl. iv, figs. 7, 7a; pl. vi, figs. 1, 1a, 2, 2a, 3, 3a.

1894. *Cladophlebis inclinata* Font.? in Diller & Stanton: Bull. Geol. Soc. Am., Vol. V, p. 450. (Pl. LXV, Fig. 8.)

1894. *Aspidium heterophyllum* Font. (part, quoad Cat. U. S. Nat. Mus., No. 3992) in Diller & Stanton: Loc. cit. (Pl. LXV, Fig. 7.)
1895 [1896]. *Cladophlebis inclinata* Font.? in Stanton: Bull. U. S. Geol. Surv., No. 133, p. 15. (Pl. LXV, Fig. 8.)
1895 [1896]. *Aspidium heterophyllum* Font. (part, quoad Cat. U. S. Nat. Mus., No. 3992) in Stanton: Loc. cit. (Pl. LXV, Fig. 7.)

Several specimens of a small fern that seems to be *Cladophlebis parva* were found. This fern of the Lower Potomac beds of Virginia appears to be rare in the collections now being described.

The most complete specimen is that figured on Pl. LXV, Fig. 5. It is the terminal portion of a penultimate pinna, which shows several ultimate pinnæ that pass into pinnules toward the tip of the principal pinna. The ultimate pinnæ in the lower portion of this fragment carry small, triangular, falcate pinnules which, although they are for the most part poorly preserved, show the character of *C. parva*. Fig. 6 represents a fragment of an ultimate pinna from low down on the frond, where the pinnules are of larger size than those represented in Fig. 5. These are exactly like the pinnules of the Lower Potomac formation.

The plant occurs at localities Nos. 9, 18, and 22.

Cladophlebis Browniana (Dunker) Seward.

Pl. LXV, Figs. 9–11.

1846. *Pecopteris Browniana* Dunk.: Monogr. d. Norddeutsch. Wealdenbildung, p. 5, pl. viii, fig. 7.
1874. *Alethopteris ? Browniana* (Dunk.) Schimp.: Pal. Vég., Vol. III, p. 502.
1894. *Cladophlebis Browniana* (Dunk.) Sew.: Wealden Flora, Pt. I, p. 99, pl. vii, fig. 4.
1894. *Cladophlebis inclinata* Font.? in Diller & Stanton: Bull. Geol. Soc. Am., Vol. V, p. 450, quoad Cat. U. S. Nat. Mus., No. 3996. (Pl. LXV, Fig. 9.)
1895 [1896]. *Cladophlebis inclinata* Font.? in Stanton: Bull. U. S. Geol. Surv., No. 133, p. 15, quoad Cat. U. S. Nat. Mus., No. 3996. (Pl. LXV, Fig. 9.)

From the number of specimens found, and the localities yielding them, a small fern identical with *Cladophlebis Browniana* must have been one of the most characteristic plants in the flora of the time of deposition of the Shasta formation. The fossils of this species are, however, quite imperfect, being found only in the form of small fragments of ultimate pinnæ. They are numerous enough to show the character

of the plant pretty well, and there is little doubt that it is the widely diffused *Cladophlebis Browniana* of the Lower Cretaceous. Some of the pinnules, as those depicted in Fig. 10, show traces of sori too obscure for their character to be made out with certainty. Yokoyama[a] had already noticed sori like those of Aspidium on pinnules of this fern. The sori of the Shasta fossil also appear similar to those of Aspidium.

I have selected three specimens to be figured, out of the many yielded by this plant. Pl. LXV, Fig. 10 represents a fragment of an ultimate pinna, with pinnules of the largest size seen. This shows traces of sori. Fig. 11 represents the terminal portion of an ultimate pinna with normal pinnules. Fig. 9 represents the specimen originally referred with doubt to *Cladophlebis inclinata*.

The plant occurs most abundantly at localities Nos. 1, 17, 19, 20, 21, 22, and 23.

CLADOPHLEBIS FALCATA Fontaine.

Pl. LXV, Figs. 12–14.

1889. *Cladophlebis falcata* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 72, pl. iv, figs. 8, 8a; pl. v, figs. 1, 1a, 2, 3, 4, 4a, 5, 5a, 6, 6a, 7, 7a; pl. vii, figs. 1, 1a, 2, 2a.

1894. *Thinnfeldia variabilis* Font. [non Vel.]? in Diller & Stanton: Bull. Geol. Soc. Am., Vol. V, p. 450. (Pl. LXV, Fig. 14.)

1895 [1896]. *Thinnfeldia variabilis* Font. [non Vel.]? in Stanton: Bull. U. S. Geol. Surv., No. 133, p. 15. (Pl. LXV, Fig. 14.)

A number of specimens of a large Cladophlebis were found, which can not be distinguished from *C. falcata* Font. of the Lower Potomac beds of Virginia. Pinnules of both large and small size, such as were seen in the Virginia specimens, were obtained. The large pinnules seem to come from lower down on the frond and the smaller from higher up on it. From the number of specimens found at some of the localities yielding the plant, it must have been common at those places. It does not, however, seem to have been abundant at many places, for most of the localities show but few specimens. The specimens are all in the form of fragments of ultimate pinnæ, which show only a few pinnules, or of single detached fragments of pinnules. The parts shown, however, are well preserved, for the plant seems to have had a thick leathery texture.

[a] Jour. Coll. Sci., Imp. Univ. Japan, Vol. VII, Pt. III, p. 218, pl. xxiv, figs. 2, 3; pl. xxvii, figs. 1–4, 5c, 5d.

Pl. LXV, Fig. 12 gives the greater portion of one of the larger pinnules, all that is preserved, and Fig. 13 represents a fragment of an ultimate pinna. This is the largest fragment that was found. Fig. 14 shows the small fragment formerly referred with doubt to *Thinnfeldia variabilis*.

This fossil is found at localities Nos. 9, 14, 18, 19, 20, and 22. It is most abundant at locality No. 22.

CLADOPHLEBIS UNGERI (Dunker) Ward n. comb.[a]

Pl. LXV, Figs. 15, 16.

1846. *Pecopteris Ungeri* Dunk.: Monogr. d. Norddeutsch. Wealdenbildung, p. 6, pl. ix, fig. 10.
1846. *Pecopteris polymorpha* Dunk. [non Brongn.]: Op. cit., p. 6, pl. vii, fig. 5.
1869. *Pecopteris Dunkeri* Schimp.: Pal. Vég., Vol. I, p. 539.
1877. *Pecopteris exiliformis* Geyler: Palaeontographica, Vol. XXIV, p. 226, pl. xxx, fig. 1.
1890. *Aspidium Dunkeri* (Schimp.) Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 101, pl. xxii, figs. 9, 9a, 9b; pl. xxv, figs. 11, 11a, 12; pl. xxvi, figs. 2, 2a, 8, 8a, 9, 9a, 18, 18a; pl. liv, figs. 3, 3a, 9, 9a.
1894. *Cladophlebis Dunkeri* (Schimp.) Sew.: Wealden Flora, Pt. I, p. 100, pl. vii, fig. 3.
1894. *Aspidium Dunkeri* (Schimp.) Font.? Fontaine in Diller & Stanton: Bull. Geol. Soc. Am., Vol. V, p. 450. (Pl. LXV, Fig. 16.)
1895 [1896]. *Aspidium Dunkeri* (Schimp.) Font.? Fontaine in Stanton: Bull. U. S. Geol. Surv., No. 133, p. 15. (Pl. LXV, Fig. 16.)

Two small bits of a fern were found at locality No. 9 which can not be distinguished from the plant named *Pecopteris Dunkeri* by Schimper. This, from the finding on it, in the Lower Potomac of Virginia, of sori like Aspidium,[b] I regard as an Aspidium.[c] The California specimens

[a] Schenk, who had seen Dunker's specimens says (Palaeontographica, Vol. XIX, p. 215) that he is unable to distinguish his *Pecopteris Ungeri* from his *P. polymorpha*, and treats them as synonyms, as did Schimper (Pal. Vég., Vol. III, p. 499) and as does also Mr. Seward (Wealden Flora, Pt. I, p. 100). As the *P. polymorpha* was preoccupied by the well-known Carboniferous species so named by Brongniart in 1828, Schimper (Pal. Vég., Vol. I, p. 539) renamed it *P. Dunkeri* before Schenk had pointed out its identity with *P. Ungeri*. That specific name must be restored to it, and as there is a pretty general agreement that it belongs to Cladophlebis the above combination necessarily results.—L. F. W.

[b] Monogr. U. S. Geol. Surv., Vol. XV, pp. 101–102, pl. xxii, figs. 9, 9a.

[c] Apropos of this Mr. Seward says (Wealden Flora, Pt. I, p. 102): "Fontaine's examples of *Aspidium Dunkeri* undoubtedly belong to that species, but the fertile pinnule, pl. xxii, fig. 9a, on which apparently the reference to Aspidium is based, seems hardly sufficient evidence for assuming identity with the recent genus." If, however, this species is thus demonstrated to have the indusia of Dryopteris, that seems to establish the reproductive characters of the genus Cladophlebis, hitherto unknown.—L. F. W.

are small fragments of ultimate pinnæ that have a few very characteristic pinnules. This plant has such decided features that even small fragments suffice to identify it.

CLADOPHLEBIS ALATA Fontaine?

Pl. LXV, Figs. 17–21.

1889. *Cladophlebis alata* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 77, pl. xix, figs. 5, 5a.

1889. *Pecopteris strictinervis* Font.: Op. cit., p. 84, pl. xiii, figs. 6, 6a, 7, 7a, 8, 8a; pl. xix, figs. 9, 9a; pl. xx, figs. 3, 3a; pl. xxii, figs. 13, 13a; pl. clxx, figs. 5, 5a, 6, 6a.

1894. *Cladophlebis inclinata* Font.? in Diller & Stanton: Bull. Geol. Soc. Am., Vol. V, p. 450, quoad Cat. U. S. Nat. Mus., No. 3996. (Pl. LXV, Fig. 21.)

1895 [1896]. *Cladophlebis inclinata* Font.? in Stanton: Bull. U. S. Geol. Surv., No. 133, p. 15, quoad Cat. U. S. Nat. Mus., No. 3996. (Pl. LXV, Fig. 21.)

In the collections from the Shasta formation of California there are many specimens that show only small bits of ferns. They are small fragments of the ultimate pinnæ of ferns that have pinnules of small size, of the type of Pecopteris or Cladophlebis. They are not found attached to a rachis and are too imperfect to admit of positive determination. They clearly belong to several different species. All that can be done in these cases is to name the plants with which they show most affinity. Larger and better specimens are required to describe or to identify them.

Numerous specimens of a small fern were found that have much resemblance to *Cladophlebis alata* Font. (*Pecopteris strictinervis* Font.),[a] of the Lower Potomac beds of Virginia. The fragments show only bits of detached ultimate pinnæ, carrying a few, and mostly imperfect, pinnules. These can not be easily distinguished from those of *P. strictinervis*, but where the material is so imperfect positive identification can not be made.

Pl. LXV, Fig. 17, gives the termination of an ultimate pinna and is the most perfect specimen found. Fig. 18 represents a small bit of an ultimate pinna, with a few imperfect pinnules of the largest size seen. Fig. 19 gives a fragment from a similar portion of the frond, with pinnules of intermediate size. Fig. 20 represents the specimen formerly referred with doubt to *Pecopteris strictinervis*.

The plant occurs in numerous specimens at locality No. 22, and in only one or two at localities Nos. 9, 18, and 19.

[a] See pp. 158–160.

Family MATONIACEÆ.

Genus MATONIDIUM Schenk.

Matonidium Althausii (Dunker) Ward.[a]

Pl. LXV, Figs. 22, 23.

1844. *Cycadites Althausii* Dunk.: Programm d. höheren Gewerbschule in Cassel, 1843–1844, p. 7.
1846. *Pecopteris Althausii* Dunk.: Monogr. d. Norddeutsch. Wealdenbildung, p. 5, pl. ii, fig. 2.
1846. *Pecopteris polydactyla* Göpp. in Dunker: Op. cit., p. 5, pl. vii, fig. 4.
1846. *Pecopteris Conybeari* Dunk.: Op. cit., p. 7, pl. ix, figs. 8, 8a.
1846. *Alethopteris elegans* Göpp. in Dunker: Op. cit., p. 8, pl. vii, figs. 7, 7a.
1849. *Pecopteris elegans* (Göpp.) Brongn. [non (Göpp.) Germ nec Sternb.]:[b] Tableau, p. 107.
1852. *Alethopteris Gœpperti* Ett.: Abh. d. k. k. Geol. Reichsanst., Vol. I, Abth. III, No. 2, p. 16, pl. v.
1865. *Laccopteris Phillipsii* Zign.: Osserv. sulle Felci Foss. dell' Oolite, p. 37.
1869. *Laccopteris Gœpperti* (Ett.) Schimp. [non Schenk[c]]: Pal. Vég., Vol. I, p. 582, Atlas, pl. xxxi, figs. 5–8.
1871. *Matonidium Gœpperti* (Ett.) Schenk: Palaeontographica, Vol. XIX, p. 220 [18], pl. xxvii [vi], fig. 5; pl. xxviii [vii]; pl. xxx [ix], fig. 3.
1888. *Matonidium polydactylum* (Göpp.) Schenk: Die fossilen Pflanzenreste, p. 39.
1891. *Laccopteris polydactyla* (Göpp.) Sap.: Plantes Jurassiques, Vol. IV, p. 384.
1894. *Osmunda dicksonioides* Font.? in Diller & Stanton: Bull. Geol. Soc. Am., Vol. V, p. 450, quoad Cat. U. S. Nat. Mus., No. 4004. (Pl. LXV, Fig. 23.)
1895 [1896]. *Osmunda dicksonioides* Font.? in Stanton: Bull. U. S. Geol. Surv., No. 133, p. 15, quoad Cat. U. S. Nat. Mus., No. 4004. (Pl. LXV, Fig. 23.)
1899. *Matonidium Althausii* (Dunk.) Ward: Nineteenth Ann. Rep. U. S. Geol. Surv., 1897–98, Pt. II, p. 653, pl. clx, figs. 5–8.

Among the fragmental fossils in the collections that are insufficient for positive determination, two imprints, strikingly like *Matonidium Althausii*, were found. Although they can not be determined positively as that plant, they are certainly different from the other ferns found,

[a] I repeat the synonymy of this species as given in my paper on the Black Hills (Nineteenth Ann. Rep. U. S. Geol. Surv., Pt. II, p. 653), with a few changes. *Laccopteris Phillipsii* Zign. was there omitted by inadvertence, and *Pecopteris explanata* Trautsch. should have been marked as doubtful, or omitted. The latter course is now pursued. No explanation was then made as to why this combination must be adopted, as it was sufficiently clear from the synonymy, since the *Cycadites Althausii* Dunk. was described in 1844 and figured as *Pecopteris Althausii* Dunk. in 1846, and no one questions its being this species.—L. F. W.

[b] Two Carboniferous species have been given this name.—L. F. W.

[c] Schenk (Foss. Fl. d. Grenzsch., 1867, p. 94) gave this name to a Rhetic species.

and may be doubtfully referred to the Wealden species. The impressions are of fragments of ultimate pinnæ, which show a few pinnules without sori. Pl. LXV, Fig. 22, gives a representation of the best specimen found. Fig. 23 represents the specimen formerly referred with doubt to *Osmunda dicksonioides*.

It occurs at localities Nos. 9 and 21.

Family GLEICHENIACEÆ.

Genus GLEICHENIA Smith.

GLEICHENIA NORDENSKIÖLDI Heer?

Pl. LXV, Figs. 24–29.

1874. *Gleichenia Nordenskiöldi* Heer: Fl. Foss. Arct., Vol. III, Pt. II (Kreide-Flora der Arctischen Zone), p. 50, pl. ix, figs. 6–12 (excl. figs. 11e, 11f).

1894. *Pecopteris strictinervis* Font.? in Diller & Stanton: Loc. cit. (Pl. LXV, Fig. 28.)

1894. *Aspidium heterophyllum* Font., part, quoad Cat. U. S. Nat. Mus., Nos. 3993 and 3997 in Diller & Stanton: Loc. cit. (Pl. LXV, Figs. 26, 27.)

1894. *Osmunda dicksonioides* Font.? in Diller & Stanton: Bull. Geol. Soc. Am., Vol. V, p. 450, quoad Cat. U. S. Nat. Mus., No. 4004. (Pl. LXV, Fig. 29.)

1895 [1896]. *Pecopteris strictinervis* Font.? in Stanton: Bull. U. S. Geol. Surv., No. 133, p. 15. (Pl. LXV, Fig. 28.)

1895 [1896]. *Aspidium heterophyllum* Font., part, quoad Cat. U. S. Nat. Mus., Nos. 3992 and 3997, in Stanton: Loc. cit. (Pl. LXV, Figs. 26, 27.)

1895 [1896]. *Osmunda dicksonioides* Font.? in Stanton: Loc. cit., quoad Cat. U. S. Nat. Mus., No. 4004. (Pl. LXV, Fig. 29.)

Small fragments of ultimate pinnæ of a fern with pinnules identical in character with Heer's *Gleichenia Nordenskiöldi* were found at a number of localities. The specimens occur only in such small fragments that positive determination of them can not be made. All that can be said of them is that the plant is, so far as its character can be made out, identical with Heer's fossil. The specimens are quite numerous, showing that the plant was rather common.

Pl. LXV, Fig. 24, represents a fragment possessing the largest pinnules seen, which belongs to the middle portion of some ultimate pinna. Fig. 25 gives the terminal portion of an ultimate pinna with small pinnules. None of the specimens seen were more complete than these small fragments. Fig. 26 represents the specimen No. 3992 of

the Catalogue of the United States National Museum, and Fig. 27 that numbered 3997, both of which were formerly referred to *Aspidium heterophyllum*. Figs. 28 and 29 show, respectively, the specimens originally referred with doubt to *Pecopteris strictinervis* and *Osmunda dicksonioides*.

These fossils occur at localities Nos. 9, 18, 19, 20, and 22.

Most of the fossils occur at the localities Nos. 9 and 22, being most numerous at No. 9.

GLEICHENIA ? GILBERT–THOMPSONI Fontaine n. sp.[a]

Pl. LXVI, Fig. 11.

The plant here regarded as a new species was found by Mr. Gilbert Thompson in the Shasta formation of the Lower Cretaceous of California. The locality is Pettyjohn's ranch, 12 miles west of Red Bluff, Tehama County, Cal. It was long ago submitted to Leo Lesquereux and by him determined as a Pecopteris, but without fixation of the species. The specific name here assigned to it is derived from its discoverer.

The plant, although in a fragmentary condition, is well preserved in the parts obtained and very distinct. It is of a well-marked character or facies, which is not very common in a formation so late as the Shasta formation, but which is more characteristic of the Carboniferous formation. It is not unlike *Pecopteris arborescens* (Schloth.) Brongn. of that formation. It is obviously a new species. The fossil is preserved in a fine-grained gray sandstone, which does not show any of the nerves of the pinnules except the midnerves. A portion of the penultimate rachis is preserved and to this are attached a number of ultimate pinnæ. The penultimate rachis is strong, straight, and rigid. The ultimate pinnæ have none of their tips preserved. They are linear and peculiarly rigid in aspect and must have had strong rachises and been quite long. Some of those that are preserved show a length of 6 cm., with no diminution in the size of the pinnules. The pinnules are closely crowded, oblong in form, attached by the entire base and have very obtuse tips. From the base to the end of the pinnule the same width is maintained, so that the margins are parallel. The texture of the pinnules seems to have been thick and coriaceous. In each pinnule

[a] See pp. 217–218.

there is a strong midnerve, which, after the fashion of Pecopteris, is maintained with full strength to near its end. The lateral nerves could not be made out.

This plant is probably a Gleichenia, a genus that, as Heer has made known, is common in the Kome or Lower Cretaceous of Greenland. Heer has shown that this genus passes up into the Atane or Upper Cretaceous of Greenland. This plant does not seem to be identical with any of the Greenland species. It is more robust and has larger pinnules than any of them. In the absence of fructification it can not be determined with certainty as a Gleichenia, and the generic designation must be left in doubt. Of course, it can not be of much value in determining the age of the strata that contain it. All that can be said of it is that its age might be either Lower or Upper Cretaceous.

Family MARSILEACEÆ.

Genus SAGENOPTERIS Presl.

Sagenopteris Mantelli (Dunker) Schenk.

Pl. LXV, Figs. 30–35.

1846. *Cyclopteris Mantelli* Dunk.: Monogr. d. Norddeutsch. Wealdenbildung, p. 10, pl. ix, figs. 4, 5.
1849. *Adiantites Mantelli* (Dunk.) Brongn.: Tableau, p. 107.
1869. *Aneimidium Mantelli* (Dunk.) Schimp.: Pal. Vég., Vol. I, p. 486; Atlas, pl. xxxi, fig. 13.
1871. *Sagenopteris Mantelli* (Dunk.) Schenk: Palaeontographica, Vol. XIX, p. 222 [20], pl. xxxi [x], fig. 5.
1894. *Glossozamites Klipsteini* (Dunk.) Font. in Diller & Stanton: Bull. Geol. Soc. Am., Vol. V, p. 450. (Pl. LXV, Figs. 32, 33.)
1894. *Sagenopteris Mantelli* (Dunk.) Schenk. Font. in Diller & Stanton: Loc. cit.
1895 [1896]. *Glossozamites Klipsteini* (Dunk.) Font. in Stanton: Bull. U. S. Geol. Surv., No. 133, p. 15. (Pl. LXV, Figs. 32, 33.)
1895 [1896]. *Sagenopteris Mantelli* (Dunk.) Schenk. Font. in Stanton: Loc. cit.

Three imprints of single detached pinnules of a fern were found at locality No. 12.[a] They occur on a fine-grained rock, which preserves them well and shows the nervation beautifully. The nervation and shape of the pinnules show that the plant is a Sagenopteris. An

[a] One of the specimens from locality No. 9, originally referred by him to *Glossozamites Klipsteini*, is now placed in this species. It is represented on Pl. LXV, Figs. 30–35.—L. F. W.

entire lateral pinnule, Pl. LXV, Fig. 30, and the greater portion of a terminal one, Fig. 31, occur among the impressions. These fossils can not well be distinguished from Schenk's *Sagenopteris Mantelli*,[a] which occurs in the Wealden formation of North Germany. The only difference between this and Schenk's fossil is the fact that in the California plant the pinnules are somewhat smaller than the German ones and the midrib in the terminal pinnule more prolonged. The pinnules of this Sagenopteris must have been easily detached, for in both the California and the North German specimens they have been found only in a detached condition. This type of Sagenopteris is smaller than the characteristic form of the Rhetic *S. Nilsoniana* (Brongn.) Ward (*S. rhoifolia* Presl).

One small specimen of a Sagenopteris, represented in Pl. LXV, Fig. 34, was found by Mr. Will Q. Brown "beneath the bridge at Riddles, Oreg." The specimen now in question shows portions of three leaflets, so arranged as to indicate that they belonged to the same individual plant. The most complete leaflet, which was probably the central one of the group, has its basal part nearly complete. It was probably elliptical in form, narrowing wedge-shaped to the base. The end is not preserved. It was probably 3 cm. long. Its greatest width is 13 mm. The best preserved lateral leaflet occurs on the right side. It is unsymmetrical, with the base and end not shown. The midrib disappears about one-third of the distance from the base to the end of the leaflet. The secondary nervation is strong and the anastomosis occurs at short intervals, forming small elliptical meshes. This plant, like the original *S. Mantelli*, is smaller than the Sagenopterids of the Trias and Jura. It is especially distinguished by the closeness of its anastomosis and its regular meshes.[b]

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[a] Die Foss. Flor. d. Nordwest. Wealdenform., p. 20, pl. x, fig. 5 (Palaeontographica, Vol. XIX, p. 222, pl. xxxi, fig. 5).

[b] The small specimen collected by Mr. Brown on Iron Mountain Creek most probably belongs to this species. In a letter returning it on October 21, 1901, Fontaine says:

"It is far from being an unrecognizable plant fragment. It seems to have a pronounced midnerve, running nearly to the end of the leaf, but that, I think, is due mainly to a pucker in the leaf. I think the leaflet is a Sagenopteris, most likely *S. Mantelli*." It is figured on Pl. LXV, Fig. 35.—L. F. W.

SAGENOPTERIS OREGONENSIS Fontaine n. comb.

Pl. LXV, Figs. 36–38.

1894. *Sagenopteris latifolia* Font. in Diller & Stanton: Bull. Geol. Soc. Am., Vol. V, p. 450. (Pl. LXV, Fig. 38.)

1895 [1896]. *Angiopteridium oregonense* Font. in Stanton: Bull. U. S. Geol. Surv., No. 133, p. 22 (nomen). (Pl. LXV, Figs. 36, 37.)

Pinnules probably grouped in a digitate manner at the summit of a principal stipe, number not known. Central pinnule broadly elliptical, narrowing to the base, 6 cm. long, 3 cm. wide in the widest portion, symmetrical and equilateral in form. Lateral pinnules inequilateral and unsymmetrical, oblong-elliptical, narrowing gradually to the base, 55 mm. long, 22 mm. wide in the widest portion. Both kinds of pinnules are probably supported on short stipes. The nervation is fine and closely placed. The anastomosis is formed on the same plan as in *S. nervosa*, viz, by the junction of two adjacent nerves, or by the junction of a branch with an adjacent nerve soon after forking. It is, however, more frequent than in *S. nervosa*. The midnerve in all pinnules is very strong in their basal portions and splits up into nerves before reaching the middle portion. These latter, where the midnerve is present, leave it at a small angle and proceed to the margin of the pinnule with a very slight outward curvature. The midnerve, unlike that of *S. nervosa*, is flat, and it is proportionally stronger in the basal portion of the pinnule, although less woody in appearance.

This plant differs from *S. nervosa* in a number of points. It is smaller in size. The midnerve differs in the points previously mentioned. The lateral and secondary nerves are closer and finer, and they anastomose more frequently. The form of the pinnules in this plant much resembles that of those of *S. Nilsoniana* (Brongn.) Ward (*S. rhoifolia* Presl) of the Rhetic formation, but the nervation is closer and finer, while the midnerve is not prolonged so far in the pinnule.

While the number of features by which this plant differs from *S. nervosa* is sufficient to justify its separation, provisionally, as a distinct species, still, as the amount of material is small, it is possible that they may be the same, and in a larger number of specimens connecting links might be found.

This plant was formerly determined by me as a new species of Angiopteridium, for which the specific name *oregonense* was suggested. With this name it was quoted by Mr. Stanton in Bulletin No. 133 of the United States Geological Survey. A careful reexamination of it shows anastomosis of the nerves, which indicates that it is not Angiopteridium, but a new species of Sagenopteris.

This fern was found in three specimens, two at the locality near Riddles, Oreg., and one at locality No. 3. One of the specimens found near Riddles has an excellently preserved imprint of an entire lateral pinnule. The other shows a nearly entire middle pinnule. The former is represented in Pl. LXV, Fig. 36, and the latter in Fig. 37. Fig. 38 represents the specimen originally referred to *S. latifolia*.

SAGENOPTERIS ELLIPTICA Fontaine.

Pl. LXV, Figs. 39, 40.

1889. *Sagenopteris elliptica* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 149, pl. xxviii, figs. 9, 11–15, 15a, 16, 16a.

Several specimens of a fern were found that seem to be *Sagenopteris elliptica* Font., of the Lower Potomac formation of Virginia. The fossils are in the form of detached pinnules, which are, in most cases, entire. These have a close resemblance to the Potomac fossil and can hardly be a different species from it. The pinnules vary a good deal in size. The smallest are rather smaller than any seen of the Potomac plant, and the largest are of the same size with the largest of that plant. Two or three of the smaller-sized pinnules have a more obtuse tip than any of the Potomac fossils. One of these, given in Pl. LXV, Fig. 40, is almost spatulate in form. Possibly these may belong to a different species of Sagenopteris. The imprints as a rule show the elongate elliptical form of the Virginia plant, with the midrib prolonged beyond the middle of the pinnule. Pl. LXV, Fig. 39, gives a pinnule of the largest size, which shows well these features. It is at the base somewhat unsymmetrical, the lamina on one side being broader than on the other, owing probably to the fact that this is a lateral pinnule.

The plant seems to be more common than the other species of Sagenopteris, but still is not very common. It occurs at localities Nos. 1, 18, 19, and 21.

SAGENOPTERIS NERVOSA Fontaine n. sp.

Pl. LXV, Figs. 41–45.

A number of fragments of detached pinnules of a fern with anastomosing nerves which seems to be a new species of Sagentopteris were found at several localities. None of the specimens show the pinnules entire, and the nervation is not very distinct, but by taking imprints of different pinnules, and different portions of these, a pretty good description can be made out. This, however, owing to the imperfection of the material, can not be regarded as certainly accurate.

Pinnules very large, probably grouped in a digitate manner at the summit of a principal stipe. The central pinnule is elliptical and symmetrical in form, narrowing gradually to the base. It is at least 8 cm. long and 3 cm. wide. The size of the other, or lateral pinnules, could not be made out, but they appear to be somewhat smaller, inequilateral, and unsymmetrical in form. The nerves are unusually strong and they are rather remote. The midnerve is rounded and very strong in the middle pinnule toward its base, and it ends in a short stipe. Toward the middle of the pinnule it splits up into nerves. The nerves in the lower portion of the pinnule go off very obliquely from the midnerve, and curve gradually away from it to the margin of the pinnule, forking repeatedly. In the upper portion the branches into which the midnerve splits up by their repeated forking fill the lamina of the pinnule. The anastomosis is most commonly formed by a branch of a nerve joining an adjacent nerve, but sometimes by two adjacent branches coalescing.

Pl. LXV, Fig. 41, represents the basal portion of a middle pinnule, Fig. 42 the upper portion of a large pinnule, probably a middle one, and Fig. 43 the tip of a lateral pinnule. Fig. 44 gives an enlargement of a portion of a pinnule to represent the character of the nerves. Fig. 45 represents the specimen from Riddles, Oreg.

This plant occurs at localities Nos. 16 and 18, in the California district, and in the Horsetown beds near Riddles, Oreg. At least a small fragment was found there, showing the characteristic nervation. The plant seems to have been rather rare at all the localities.

SAGENOPTERIS ? sp. Fontaine.

Pl. LXV, Fig. 46.

1894. *Sagenopteris* sp.? Font. in Diller & Stanton: Bull. Geol. Soc. Am., Vol. V, p. 450 (nomen.).

1895 [1896]. *Sagenopteris* sp. Font. in Stanton: Bull. U. S. Geol. Surv., No. 133, p. 15 (nomen.).

At locality No. 9 occur several impressions of a fern which is apparently a Sagenopteris, but the leaflets are too imperfect and the nervation is too poorly shown to permit its specific character to be made out. The character of the anastomosis of the nerves is similar to that of *S. elliptica*, of the Lower Potomac of Virginia, but the nerves are stronger. This plant may be identical with some of the ferns with reticulated nervation in the Great Falls flora that Doctor Newberry placed with great hesitation in the genus Chiropteris. He seems to have separated them from Sagenopteris, with which genus, as it seems to me, they best agree, solely on account of the sparing anastomosis. But this, in the Great Falls fossils, is hardly less frequent than in *S. elliptica* of the Lower Potomac, and Doctor Newberry's *Chiropteris spatulata* is much like *Sagenopteris elliptica*.

Genus HAUSMANNIA Dunker.

HAUSMANNIA ? CALIFORNICA Fontaine n. sp.

Pl. LXV, Fig. 47.

A single specimen of a plant of doubtful character was found at locality No. 18 in the Knoxville beds. It is a portion of the lower part of a leaf that seems to have narrowed to its base. As the full width of the leaf is not preserved and the margin is apparently not entire in any portion, it is not possible to determine its original form. The plan of the nervation indicates a flabellate and digitately lobed leaf, but if it were lobed after the fashion of Hausmannia it was not cut into such narrow laciniæ as Dunker's *Hausmannia dichotoma*,[a] for the fragment obtained, although not so broad as it was originally, shows no subdivision, and it is wider than any of the segments of Dunker's plant. The nervation shows several nerves of equal strength and not diminishing in size by division. These nerves converge toward the base of the leaf so as apparently to unite, while in the opposite

[a] Monogr. d. Norddeutsch. Wealdenbildung, p. 12, pl. v, fig. 1; pl. vi, fig. 12.

direction they diverge and fork dichotomously at long intervals, this forking not diminishing their size. This nervation is much like that of Hausmannia, but the forking takes place at shorter intervals than in Dunker's species. The secondary nervation is very obscure, and all nervation of lesser rank is not shown. The secondary nerves, which are occasionally vaguely shown, appear to stand nearly at right angles with the primary ones. The surface of the fragment of the leaf is granulated as if from sori scattered over it. The details of these could not be made out. This granulation, if caused by sori, together with the primary nerves, suggests an affinity with Hausmannia, but the true place of the plant is very problematic.

Family MARATTIACEÆ.

Genus ANGIOPTERIDIUM Schimper.

ANGIOPTERIDIUM CANMORENSE Dawson.?

Pl. LXVI, Figs. 1–4.

1892. *Angiopteridium canmorense* Dn.: Trans. Roy. Soc. Canada, Sect. IV, Vol. X, p. 83, fig. 2 on p. 83.

1894. *Angiopteridium nervosum* Font.? in Diller & Stanton: Bull. Geol. Soc. Am., Vol. V, p. 450. (Pl. LXVI, Fig. 4.)

1894. *Angiopteridium canmorense* Dn.? Font. in Diller & Stanton: Loc. cit. (Pl. LXVI, Fig. 1.)

1895 [1896]. *Angiopteridium nervosum* Font.? in Stanton: Bull. U. S. Geol. Surv., No. 133, p. 15. (Pl. LXVI, Fig. 4.)

1895 [1896]. *Angiopteridium canmorense* Dn.? Font. in Stanton: Loc. cit. (Pl. LXVI, Fig. 1.)

Sir William Dawson[a] has described from Canmore, in the Cascade coal basin of the Rocky Mountains, a fern that is much like a plant found in several specimens at some of the California localities. As, however, the specimens from California are all in the form of detached pinnules, which in every case are in fragments, the material does not suffice for positive identification. The California plant, however, shows several of the characteristic features of *Angiopteridium canmorense*. The pinnules have the same narrow form, rigid aspect, and comparatively very stout midrib prolonged to the ends of the pinnules. The lateral nervation is

[a] Correlation of Early Cretaceous Species, p. 83, fig. 2.

close, apparently unbranched, and at right angles with the midrib. It seems to have been rather abundant.

This plant, in the narrow rigid pinnules, looks a good deal like *Angiopteridium auriculatum* Font., of the Lower Potomac of Virginia,[a] but the nervation is entirely different, while the base of the pinnules narrows and is not auriculate.

Pl. LXVI, Fig. 1, gives the terminal portion of one of the narrowest pinnules. Fig. 2 represents a portion, apparently the middle part, of a pinnule. Fig. 3 gives the basal portion, but not the exact base, of a pinnule. Fig. 4 represents the specimen that was formerly referred to *A. nervosum* with doubt.

The plant now in question occurs at localities Nos. 7, 9, 13, 19, and 22.

ANGIOPTERIDIUM STRICTINERVE Fontaine.

Pl. LXVI, Figs. 5–7.

1889. *Angiopteridium strictinerve* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 116, pl. xxix, figs. 8, 8a, 9.

Numerous specimens of fragments of pinnules occur at several localities that seem to belong to *Angiopteridium strictinerve* Font., of the Lower Potomac formation of Virginia. Some of the specimens are well enough preserved to show their character fairly well, but many are too imperfect to permit positive identification. Those showing recognizable characters are too near the Potomac plant to allow their separation into a species distinct from it. The specimens figured will give a good idea of the best preserved of these forms. The impressions occur only in the form of fragments of detached pinnules, none of which are well enough preserved to show the dimensions of the pinnules. It is possible that these various forms, which, in this paper, I have regarded as Angiopteridium, may belong to Nilsonia. They show, however, more of the character of Angiopteridium than of Nilsonia, and no trace of the division of the laminæ of the pinnules into laciniæ was ever seen. The specimens from the Shasta group are not better preserved than those of the Potomac, and do not add anything to our knowledge of this plant. The nervation is rarely visible, as the leaf substance of the pinnules seems to have been thick and coriaceous. The lateral nerves, in the only specimen which

[a] Monogr. U. S. Geol. Surv., Vol. XV, p. 113, pl. vii, figs. 8–11; pl. xxviii, fig. 1.

shows them, seem somewhat different from those of the Potomac plants, for they go off more nearly at a right angle from the midrib and are mostly unbranched.

The pinnules were evidently quite long and narrow, as is shown in the specimen given in Fig. 5, which represents a fragment of the middle portion of a pinnule. Fig. 6 gives the terminal portion of a pinnule, which must have been larger than that represented by Fig. 5. Fig. 7 shows the lateral nervation.

The undoubted specimens of this plant are not very numerous. They occur at localities Nos. 9, 19, 20, and 22. The doubtful specimens are numerous, and they occur at localities Nos. 9, 14, 19, and 23. They are mostly found at the last locality.

ANGIOPTERIDIUM STRICTINERVE LATIFOLIUM Fontaine.

Pl. LXVI, Figs. 8–10.

1889. *Angiopteridium strictinerve latifolium* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 116, pl. xxx, figs. 1, 5.

1895 [1896]. *Angiopteridium nervosum* Font. in Stanton: Bull. U. S. Geol. Surv., No. 133, p. 22. (Pl. LXVI, Figs. 9, 10.)

A number of fragments of a fern were found that appears to be *Angiopteridium strictinerve latifolium* Font., of the Lower Potomac of Virginia. The largest and best preserved of these fragments is represented in Pl. LXVI, Fig. 8. This is a portion of a pinnule, probably its middle part. It shows some of the midrib and of the lamina on one side of the midrib. It must have been a pinnule at least 5 cm. wide. There is no way to estimate its length, or indeed that of any of the pinnules, since they are found only as small fragments. The midrib is quite strong. The lateral nerves are also strong and have the character shown in the Potomac plant.

This form occurs at localities Nos. 16, 19, and 23, and near Riddles, Oreg. A considerable number of fragments of pinnules are found at No. 23, as well as fragments of pinnules of a smaller Angiopteridium, which seems to be the typical *A. strictinerve.*

This plant was formerly determined by me as *A. nervosum*, and it is quoted as such by Dr. T. W. Stanton in Bulletin No. 133 of the United States Geological Survey, page 22, but it proves, on further examination,

to belong to this species. The specimens on which the former determination was based are represented in Pl. LXVI, Figs. 9, 10, and were collected in the Horsetown beds near Riddles, Oreg.

Family ODONTOPTERIDEÆ.

Genus CTENOPTERIS Brongniart.

Ctenopteris integrifolia Fontaine.?

Pl. LXVI, Figs. 12, 13.

1889. *Ctenopteris integrifolia* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 158, pl. lxii, fig. 2; pl. lxv, figs. 3, 3a.

Among the fossils of the Shasta formation two imprints were found that have a problematic nature. They consist of small fragments of leaves that show only the bases of segments, which have the appearance of a cycad in some points. Although the fragments are small, they are very distinct. The segments are 4 mm. in width, and as the basal portions only are shown their length is not disclosed. They are attached by their entire base to the side of the midrib, are separate to the base, and slightly decurrent on the lower side. The nerves are slender but distinct. They go off obliquely from the midrib in a parallel manner throughout the entire width of the segment, and in this respect resemble Ctenophyllum and Dioonites. But, unlike these genera, the nerves are forked one or more times at varying distances from their insertion on the midrib. The amount of material is entirely too small to permit a positive determination of this plant, but from its resemblance to the peculiar genus Ctenopteris found in the Lower Potomac of Virginia, and more especially *C. integrifolia* Font., I have referred the plant to that species. This, however, can be done only with doubt and for the sake of reference. It is to be noted that the Virginia plant was not fully made out, owing to the insufficiency of the material.

Pl. LXVI, Fig. 12, gives a small bit of the leaf, with the bases of two segments, and Fig. 13 a portion enlarged, to show nervation.

This plant occurs at localities Nos. 1 and 4.

Order EQUISETALES.

Family EQUISETACEÆ.

Genus EQUISETUM Linnæus.

EQUISETUM TEXENSE Fontaine. ?

Pl. LXVI, Fig. 14.

1893. *Equisetum texense* Font.: Proc. U. S. Nat. Mus., Vol. XVI, p. 263, pl. xxxvi, fig. 1.
1894. *Equisetum texense* Font. ? in Diller & Stanton: Bull. Geol. Soc. Am., Vol. V, p. 450.

One of the rock specimens collected by Messrs. Stanton, Diller, and Storrs at locality No. 11 shows a rather obscure impression of what was evidently a stem. It contains what appears to be an imperfectly preserved sheath, indicating that it is the stem of some small Equisetum. Besides this, there are on the same piece of rock several other imprints still more obscure of what seems to be the same kind of stem. The stems seem to have originally been woody and straight, but are now much macerated and mostly decorticated. The sheath, which is still partly preserved, is swollen and reminds one of the plant from the Trinity formation of the Comanche series of Texas,[a] named by the writer *Equisetum texense*. The size of the stem also agrees well with the Texas plant. As, however, the material is scanty and poorly preserved, the identification can not be positive.

Phylum SPERMATOPHYTA.

Class GYMNOSPERMÆ.

Order CYCADALES.

Family CYCADACEÆ.

Genus DIOONITES Miquel.

DIOONITES DUNKERIANUS (Göppert) Miquel.[b]

Pl. LXVI, Fig. 15.

1843. *Nilssonia pecten* Dunk.: Programm d. höheren Gewerbschule in Cassel, 1843–44, p. 7.

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[a] Notes on some fossil plants from the Trinity division of the Comanche series of Texas: Proc. U. S. Nat. Mus., Vol. XVI, p. 263, pl. xxxvi, fig. 1.

[b] Dunker sent specimens of this plant to Göppert, who referred it to Pterophyllum and named it *P. Dunkerianum* after Dunker had named it *Nilsonia pecten*. Seward and others now place it in Dioonites, and Dunker's

1844. *Pterophyllum Dunkerianum* Göpp.: Uebersicht d. Arbeiten d. Schles. Ges. f. Vaterl. Kultur, 1843, p. 134.
1846. *Pterophyllum Dunkerianum* Göpp. Dunker: Monogr. d. Norddeutsch. Wealdenbildung, p. 14, pl. ii, figs. 3, 3a, b; pl. vi, fig. 4.
1846. *Cycadites Morrisianus* Dunk.: Op. cit., p. 16, pl. vii, fig. 1.
1849. *Zamites Dunkerianus* (Göpp.) Brongn.: Tableau, pp. 62, 107.
1851. *Dioonites Dunkerianus* (Göpp.) Miq.: Tijdschr. v. d. Wis-en Naturk. Wetensch., Deel IV, p. 212 [8].
1894. *Dioonites Dunkerianus* (Göpp.) Miq. Font. in Diller & Stanton: Bull. Geol. Soc. Am., Vol. V, p. 450.

Several specimens of a plant were found at locality No. 1 that agree exactly with the plant from the Glen Rose beds of Texas,[a] which the writer identified with *Dioonites Dunkerianus* (Göpp.) Miq. of the Wealden of Hanover. The specimens show fragments of leaves, with portions of leaflets attached to the midrib, and also fragmentary detached leaflets. The midrib, as is shown in the fragment depicted in Fig. 15, is, as in the Glen Rose plant, quite strong and rigid. The leaflets, as is the case with the Texas fossil, are thick and rigid, with dense epidermis, and show no nerves distinctly. From crumpling longitudinally they sometimes exhibit what resembles a strong nerve, which on casual inspection might be taken for the single nerve of a Cycadites. There can be no question that this plant belongs to the same species as that from Texas, whether that is *D. Dunkerianus* or not.

Dioonites Buchianus (Ettingshausen) Bornemann.[b]

Pl. LXVI, Figs. 16, 17.

1852. *Pterophyllum Buchianum* Ett.: Abh. d. k. k. Geol. Reichsanst., Vol. I, Abth. III, No. 2, p. 21, pl. i, fig. 1.
1856. ? *Dioonites Buchianus* (Ett.) Born.: Org. Rest. d. Lettenkohlengruppe Thüringens, p. 57.

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specific name would have to be restored had not Miquel in 1861 (Prodromus systematic Cycadearum, p. 31) referred the Oolitic species called *Cycadites pecten* by Phillips to the genus Dioonites, making the combination *Dioonites pecten* (Phill.) Miq. The next oldest name is that of Göppert, 1844, and it happens that Miquel is also responsible for this combination.—L. F. W.

[a] Notes on some fossil plants from the Trinity division of the Comanche series of Texas: Proc. U. S. Nat. Mus., Vol. XVI, p. 265, pl. xxxvi, fig. 12; pl. xxxvii, fig. 1.

[b] I have hesitated long before deciding to retain this combination in view of all that Nathorst (Denkschr. Wien Akad., Vol. LVII, p. 46) and Seward (Wealden Flora, Pt. II, pp. 75ff) have said against placing this species in Miquel's genus Dioonites, the former creating for it the genus Zamiophyllum, and the latter referring it to Zamites. But Professor Fontaine argues the case for himself. It is true that Bornemann referred Ettings-

1870. *Dioonites Buchianus* (Ett.) Born. Schimper: Pal. Vég., Vol. II, p. 149.
1889. *Dioonites Buchianus* (Ett.) Born. Fontaine: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 182, pl. lxviii, fig. 1; pl. lxix, figs. 1, 3; pl. lxx, figs. 2, 3; pl. lxxi, fig. 1; pl. lxxii, figs. 1, 1a, 2, 2a; pl. lxxiii, figs. 1–3, 3a, 3b; pl. lxxiv.
1890. *Zamiophyllum Buchianum* (Ett.) Nath.: Denkschr. Wien Akad., Vol. LVII, p. 46 [6], pl. ii, figs. 1, 2; pl. iii; pl. v, fig. 2.
1895. *Zamites Buchianus* (Ett.) Sew.: Wealden Flora, Pt. II, p. 79, pl. iii, figs. 1–5; pl. iv; pl. viii, fig. 1.

Specimens of probable *Dioonites Buchianus*, of rather doubtful character, occur at localities Nos. 1, 15, 20, and 22. They are doubtful because they are composed of fragments of detached leaflets. But at locality No. 17, in the lower part of the Horsetown beds, Messrs. Ward and Storrs found seven specimens of this plant which admit of no doubt. They show portions of the midrib with leaflets attached. These have all the characteristic features of *Dioonites Buchianus*. Many of these features are so well marked and characteristic of this plant that there is no occasion for confounding it with any other, provided they are distinctly displayed. This makes the plant especially valuable in the comparison of the geological age of strata. It is to be noted that it occurs here in the Horsetown beds, whose age has been determined from the marine invertebrates which they contain to be Lower Cretaceous.

Figs. 16 and 17 give representations of two of these specimens.

Dioonites Buchianus seems to have had a world-wide distribution, and it has always been found only in Lower Cretaceous strata. It was first found in the Urgonian beds of Grodischt. Later the writer discov-

hausen's plant to Dioonites with doubt and in an obscure manner, but Schimper (Pal. Vég., Vol. II, p. 149) did the same thing independently, and evidently without any knowledge that Bornemann had already done so.

Mr. Seward includes in this species the Cenomanian *Pterophyllum saxonicum* Reich, so named by Reich in the Freiberg Museum, apparently only on the label, first mentioned in print by Geinitz in Gaea von Sachsen (1843), p. 134, without description, and first described and figured by Göppert in 1848 (Nov. Act. Acad. Caes. Leop. Carol. Nat. Cur., Vol. XXII, p. 362, pl. xxxviii, fig. 13) from specimens sent to him by Reich. Schimper referred this also to Dioonites (Pal. Vég., Vol. II, p. 211), but did not identify it with Ettingshausen's plant. Professor Fontaine in his Potomac Flora, pp. 182, 184, also puts the *Dioonites saxonicus* (Reich) Schimp. in the synonymy of this species, but apparently on the strength of two figures of Ettingshausen (Sitzb. Wien. Akad., Vol. LV, Abth. I, pl. i, figs. 11, 12, p. 245) and the very imperfect fragment figured by Hosius and von der Marck from the Neocomian of Westphalia (Palaeontographica, Vol. XXVI, pl. xliv, fig. 19S). He does not seem to have seen Göppert's figures of Reich's Cenomanian plant. There is no certainty that the Westphalian fragment belongs to that species. In view of this uncertainty and of the general improbability that the species persisted into the Cenomanian, I shall not follow this course. If future investigation ever makes it necessary the species must of course bear Reich's name, which has priority over that of Ettingshausen by nine years.—L. F. W.

ered it in great abundance in the basal beds of the lower Potomac of Virginia, in that portion of the formation which Professor Ward has named the "James River series." In the Virginia strata it is confined to the lowest beds, and when found the crystalline floor is but a few feet beneath. It occurs in clay lenses in sand. It is so abundant in some places that the clay is filled with the remains of the plant. These clays have in many cases so well preserved the plant that the epidermal tissue is intact, as also much of the rest of the plant, so that it can be peeled off from the stone. It has been found also in the Glen Rose beds of the Comanche series of Texas. The plant occurs in great abundance at numerous localities in strata of Neocomian age in Japan. These fossils were first described by Nathorst, and later by Yokoyama. Seward, in his account of the Wealden flora in the British Museum, states that he finds numerous fine impressions of this plant in that flora. It is quite probable that the plant does occur in the British Wealden flora, but in my opinion the forms on which he lays much stress are not *Dioonites Buchianus*. The reasons for this opinion will be given further on.

The finding of this plant and similar forms of late in different regions has led to a difference of opinion as to the proper naming of this interesting and important genus. I have had exceptional opportunities to study this plant. There is no doubt that, with the possible exception of Japan, it exists in the Virginia beds in greater abundance and better preserved than anywhere else. I have seen hundreds of specimens in all conditions of preservation. Often the fossil, as disclosed by careful stripping of the rock, was much more perfect than any portion that could be obtained for preservation. This is a great advantage that the collector has over one who depends on specimens preserved in collections. I have observed that this plant is much better and oftener preserved in the middle upper and terminal portions of the leaves than in any other part. The result is that nearly all the specimens figured by myself and those given by others come from such parts. The specimens shown in the thin clay layers found, forming numerous interstratifications with sand layers, in the banks of Dutch Gap Canal were sometimes 18 inches long. They could be obtained only in smaller fragments. The leaves must originally have been 2 or 3 feet long. Not much importance is to be attached to the amount of obliquity in the position of the leaflets

with reference to the midrib. Those lowest down stand at a large angle; it may be a right angle. The nearer you approach the end of the leaf the more oblique are the leaflets, and at the end they stand in the prolongation of the midrib. I regard the mode of attachment of the leaflets to the midrib as the most important, and it certainly is the most unvarying, feature of this plant. The leaflets are attached, not on the face of the midrib, but to the side in the plane of its upper face. The epidermis of the leaflet is continuous with that of the midrib. So far are the leaflets from being articulated with the midrib that they are remarkably persistent. They are narrowed *toward* their bases, but not *at* them, and there is no abrupt rounding off at the base as in Zamites, but they are decurrent along the midrib. The terminal leaflets are always decidedly narrower than those lower down on the midrib and, as before stated, are much more obliquely placed.

Nathorst, in describing specimens of this species obtained from Japan, has proposed Zamiophyllum as the generic name for it.[a] He objects to the name Dioonites for this plant because it is unlike Dion in having its leaflets narrowed toward the base and in having them obliquely placed. He states further that he thinks it not impossible that the plant now in question may belong to the living genus Zamia. The first objection is the only one that holds good, for, as has been stated, the second is not applicable to the leaflets in the lower portion of the leaf, and, in any case, such a feature can have no great value. Perhaps it would have been better in the original determination of the plant to have placed it in a new genus, but it does not seem fitting to rename it with such a generic appellation as Zamiophyllum. This suggests an affinity with Zamia, of which there is no evidence. It differs from Zamia in the absence of articulation of the leaflets and in their marked persistence on the midrib. Besides, the basal portions of the leaflets differ in form from those of Zamia. Seward, as before stated, describes a number of fine forms that he identifies with *Dioonites Buchianus*.[b] He includes these plants in the genus Zamites, modifying the generic description somewhat. His figures and descriptions make it plain that his fossils are different from the Potomac forms described by me as *Dioonites*

[a] Beiträge zur Mesozoischen Flora Japans, pp. 6, 7 (see synonymy, p. 245).
[b] Fossil Plants of the Wealden, Part II, pp. 75–86.

Buchianus and equally plain that they are the same with the Potomac fossil which I described as *D. Buchianus obtusifolius.*[a] In my examination of the numerous fossil specimens of *D. Buchianus* found in the Lower Potomac beds they were found to exhibit great constancy in the mode of insertion of the leaflets, when this could be made out. The only rather common variation that occurred with sufficient definiteness to give a basis for varietal distinction was in the narrowness of the leaflets of certain forms, which did not arise from the leaflets belonging to the summit of the leaves, and which did not graduate by intermediate forms into the normal *Buchianus* type. This led me to regard these as a variety (*angustifolius*) of the species. The separation was not based upon any particular mode of narrowing of the parts of the leaflets, but upon the constant recurrence of unusually narrow leaflets in the whole leaf. It is quite possible that they may be young leaves of the normal species. I did, however, find a single fine specimen of a plant resembling *D. Buchianus* which presented obvious and important differences from the normal forms. This is the specimen that I named *D. Buchianus obtusifolius.* It has the leaflets inserted *on* the upper face of the midrib by an *articulation,* and when the leaflets are separated from the midrib they leave an elliptical scar. The points of difference from the normal *Buchianus* type were so important that I hesitated long to put it in the same species with this latter. As, however, I had found but a single specimen with these characters, and as that occurred associated with numerous normal forms, I did not feel justified in regarding it as more than a variety of the species now in question. Had I found the numerous specimens showing these features that Seward has seen I should have felt compelled to separate it from *D. Buchianus* not only specifically but generically.

The objection to giving *D. Buchianus* a generic name implying affinity with the living genus Zamia—such names as Zamiophyllum of Nathorst, and Zamites, as proposed by Seward—do not apply in the case of my *D. Buchianus obtusifolius* and of Seward's plants. The name Zamites, however, has already been applied to too many different types of fossil cycads. Such different forms as *Z. Feneonis* (Brongn.) Ung. and *Z. arcticus* Göpp., it would seem, ought to be separated as at least

[a] Monogr. U. S. Geol. Surv., Vol. XV, pp. 184–185, pl. clxviii, fig. 3.

different subgenera. Seward's plants are evidently a quite different type from these. Nathorst's *Zamiophyllum Naumanni*, found in the same Japanese formation as the specimens of *Dioonites Buchianus*, which he names *Zamiophyllum Buchianum*, is a species of the same type as Seward's forms. It is probably specifically different from the latter. Nathorst's *Zamiophyllum Buchianum* and the original *Pterophyllum Buchianum* of Ettingshausen are, in my opinion, the same species as the Potomac plant. For these I prefer to retain the name *Dioonites Buchianus*. That name is established, and the genus is as near Dion as Zamia. Perhaps it would be well to make a new genus for the plants with leaflets inserted on the upper face of the midrib, like those of Seward, in order not further to extend the application of Zamites. This new genus might be called Zamiophyllum, as Nathorst proposed.

I think that some of the confusion that has arisen in the classification of cycads, based partly on the mode of insertion of the leaflets, comes from the fact that authorities have not used the descriptions "attached *to* the upper face of the midrib" and "attached *on* the upper face" always in the same sense. It may be meant, in the case of the former, that the leaflets are attached, not on the upper face and within its margin, as in the case of Seward's plants, but to the sides of it, so as to be in the same plane with the upper face of the midrib, as is true of *Dioonites Buchianus*. Certainly it is very desirable that there should be a thorough revision of the classification of the fossil cycads that are known only by their leaves. In Monograph XV of the United States Geological Survey, page 181, speaking of Bornemann's genus Dioonites,[a] as characterized by Schimper, I made the latter say that the leaflets are "sometimes expanded at base so as to extend up and down the rachis." This was a translation of Schimper's words "basique leniter pro- et decurrentibus," which he used in his synopsis of the character of Dioonites, given on page 128, Vol. II, of his Traité. It escaped my notice that on page 147 of the same volume, in giving again the character of this genus, he uses different words, viz, "e basi anguste decurrente, haud angustata."[b]

[a] The genus Dioonites was named and described by Miquel in 1851 (Over de Rangschikking der fossiele Cycadeæ; Tijdschr. v. d. Wis-en Naturk. Wetensch., Deel IV, Amsterdam, 1851, p. 211 [7]), and is so credited by Bornemann. Miquel did not refer Ettingshausen's *Pterophyllum Buchianum* to this genus. It was named from its resemblance to Lindley's living genus Dion, wrongly spelled Dioon by many authors.—L. F. W.

[b] Miquel's language for this character is as follows: "inferne retrorsum subdecurrentia."—L. F. W.

Dioonites Buchianus abietinus (Göppert) Ward n. comb.[a]

Pl. LXVII, Figs. 1–3.

1846. *Pterophyllum abietinum* Göpp. in Dunker:
Monogr. d. Norddeutsch. Wealdenbildung, p. 15, pl. vii, fig. 2.
1851. *Dioonites abietinus* (Göpp.) Miquel: Tijdschr. v. d. Wis-en Naturk. Wetensch. v. h. Kon.-Ned. Inst. Amsterdam, Deel IV, p. 212 [8].
1889. *Dioonites Buchianus angustifolius* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 185, pl. lxvii, fig. 6; pl. lxviii, fig. 4; pl. lxxi, fig. 2
1894. *Dioonites Buchianus angustifolius* Font. in Diller & Stanton: Bull. Geol. Soc. Am., Vol. V, p. 450.
1894. *Zamiophyllum Buchianus angustifolia* (Font.) Yok.: Jour. Coll. Sci. Imp. Univ. Japan, p. 224, pl. xxii, fig. 4; pl. xxv, fig. 5; pl. xxviii, figs. 8, 9.

Detached fragments of leaflets similar to *Dioonites Buchianus abietinus* Font., a plant occurring in the Lower Potomac of Virginia, were found sparingly at localities Nos. 1, 9, 17, 19, and 20. Like the similarly detached fragments resembling leaflets of *D. Buchianus*, these are of doubtful character. But at locality No. 5, in the base of the Horsetown beds, undoubted specimens, 5 in number, were found of this plant. It is to be noted that the undoubted specimens of both forms of *D. Buchianus* occur in the lower portion of the Horsetown beds. The specimens have the leaflets attached to the midrib, and they are uniformly narrow, even when attached, as in Pl. LXVII, Fig. 1, low down on the midrib.

One specimen of this plant was collected in Oregon. This specimen is a fragment of a leaf that shows 7 cm. of its length, with several leaflets on the left side of the midrib. The leaflets go off very obliquely and only their basal portions are preserved. They are 2 mm. wide, and the nerves are not visible. This plant resembles the Potomac form depicted in Monograph XV of the United States Geological Survey, pl. lxvii, fig. 6. It was collected by Mr. Will Q. Brown from a locality about one-fourth of a mile above the town of Riddles in Oregon. It occurs in a fine-grained

[a] Professor Fontaine in his Potomac Flora, p. 185, identified the Virginia plant with the form from the Wealden of north Germany, which Dunker submitted to Göppert and which the latter in a letter to Dunker named *Pterophyllum abietinum*. Miquel five years later referred it to Dioonites. Although Professor Fontaine reduced it to a subspecies of *Dioonites Buchianus* (Ett.) Born., still under the rules of nomenclature the original name of Göppert can not on that account be taken from it, but must remain as the name of the subspecies. The above combination must therefore be substituted for the name that Professor Fontaine gave it (*Dioonites Buchianus angustifolius*.—L. F. W.

gray sandstone in the creek bank. This sandstone is much like that containing the *Populus? Ricei* (see p. 266), and it is probably like that of Horsetown age.

The size of the midrib in the specimen in Pl. LXVII, Fig. 1, shows that the leaf was probably full grown, and not a young one. Fig. 2 gives leaflets attached higher up on the midrib. Fig. 3 represents the Oregon specimen.

Dioonites Buchianus rarinervis Fontaine?

Pl. LXVII, Fig. 4.

1893. *Dioonites Buchianus rarinervis* Font.: Proc. U. S. Nat. Mus., Vol. XVI, p. 264, pl. xxxvi, figs. 3, 4.

1894. *Dioonites Buchianus rarinervis* Font. in Diller & Stanton: Bull. Geol. Soc. Am., Vol. V, p. 450.

This is the terminal portion of a leaflet that in other respects, and especially in its remote, spare nerves, agrees well with the variety *rarinervis* of *Dioonites Buchianus*. The amount of material and the imperfect preservation do not permit a positive identification with that variety. It is, however, certainly *D. Buchianus*. This variety has been found only in the Glen Rose flora of Texas. The specimen was found at locality No. 11 and occurs on the same fragment of rock with the immature cone of Abietites described on page 262.

Genus NILSONIA Brongniart.

Nilsonia Stantoni Ward n. sp.[a]

Pl. LXVII, Figs. 5, 6.

Leaf unknown. Leaf segments mostly equal. Occasionally some are slightly wider than the average. The segments stand generally at right angles with the midrib, but in some cases are directed slightly forward, so as to be somewhat falcate. They are separate to the midrib and of the same width from base to summit. On an average they are 1 cm. wide and 15 mm. long. Their tips are rounded, truncate, or else elliptically narrowed. The nerves are not well disclosed, but are fine,

[a] The name given to this species by Professor Fontaine in his manuscript was preoccupied. I therefore name it for Dr. T. W. Stanton, who collected the specimens.—L. F. W.

single, and close, being two to a millimeter. They stand at right angles to the midrib. As usual in Nilsonia, the bases of the segments pass over the margin of the midrib and meet in a raised line. This lies in the middle of the midrib and is straight.

This is a pretty distinctly characterized Nilsonia, although the amount of material is small and the imprints are imperfect. It is not very near any hitherto described plant unless it be *N. comtula* Heer[a] from the Brown Jura of Ajikit and Bulun in Siberia. It is, however, more uniform in the character of its segments than this plant, and the nerves are not so close.

Pl. LXVII, Fig. 5, represents a portion of a leaf with several segments more or less complete, which indicate the slight inequality sometimes existing in them. Fig. 6 gives another small fragment which shows the greater portion of a segment with its base and insertion very well preserved. Only the extreme tip of the segment is wanting, and it shows well the character of the average segments. On this segment is shown a feature not uncommon in the segments of the leaves found here. This is a slight narrowing of the segment just above the base. It is due to distortion from pressure.

Six specimens of the plant were found. It occurs at locality No. 9, only in small fragments of leaves, which have several segments.

Nilsonia californica Fontaine.

Pl. LXVII, Fig. 7.

1894. *Pterophyllum californicum* Font. in Diller & Stanton: Bull. Geol. Soc. Am., Vol. V, p. 450 (nomen).[b]

[a] Flor. Foss. Arct., Vol. V, Pt. II (Beiträge zur Foss. Fl. Sibiriens und d. Amurlandes), pp. 19–20, pl. iv figs. 10–16.

[b] The list of species given in this paper contains the names without descriptions of all the plants that had been collected in the Shasta group at that time, which as I have stated (pp. 140–141) were sent to Professor Fontaine and determined by him. In his report which was sent to me on the 23d of February, 1894, and immediately placed in Mr. Diller's hands, this new species was fully described as follows:

"*Pterophyllum californicum* n. sp., one specimen. This is a new species of that type of Pterophyllum which is very characteristic of the Lower Cretaceous, and is illustrated by *P. Brongniarti* Morris, of the Wealden of northern Germany, and by *P. concinnum* Heer, of the Kome beds of Greenland. The single specimen, although but a small fragment of a leaf, shows several leaflets, with all their character distinctly displayed. It maybe described as follows: *Pterophyllum californicum*. Leaf unknown; leaflets attached by a widened base to the side of the midrib, going off at a large angle, approximating a right angle, falcately curved, varying irregularly in width. The average leaflet is 3 mm. in width and 15 mm. in length. The ends of the leaflets are very obtuse

1894. *Nilsonia pterophylloides* Yok. [non Nath.[a]]: Jour. Coll. Sci. Imp. Univ. Japan, Vol. VII, Pt. III, p. 228, pl. xxii, figs. 8–10; pl. xxv, fig. 7.

1895 [1896.] *Pterophyllum californicum* Font. in Stanton: Bull. U. S. Geol. Surv., No. 133, p. 17.

A single specimen of a cycad was found at locality No. 14, which appears identical with the plant named *Nilsonia pterophylloides* by Yokoyama, from strata of Neocomian age in Japan. The California specimen, depicted in Fig. 44, is a fragment of a leaf 45 mm. long, which bears a number of segments, some of which are entire and which are pretty well preserved. The segments have approximately the same shape as those of Yokoyama's plant. The nerves are about 10 in number, single and parallel. The specimen looks a good deal like a Pterophyllum, as it has suffered somewhat from maceration, which has removed the epidermis of the midrib, but careful inspection shows that the bases of some of the segments are still preserved and that they pass over the margin of the midrib to meet in its center, as in Nilsonia. The segments are not quite so uniform in width as those of the Japanese plant, some being slightly wider than others, but not markedly so. The length of the segments is 15 mm. and their average width is about 6 mm. The form is clearly one not hitherto found in the Lower Cretaceous of North America and it is so near that of Yokoyama's plant that it seems identical. Besides this, the Japanese beds have yielded a number of others identical with forms from the Lower Cretaceous of North America.

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and rounded. The nerves are distinct, closely placed, and in the average leaflets 8 in number, but are more numerous in the wider leaflets, which may be half as wide again as the average ones.

"This Pterophyllum resembles in some points both of the species with which I have compared it, and apparently it is a connecting link between them. Probably all three of these plants are varieties of one species. Its general appearance is much like that of *P. concinnum*, so far as the shape and size of the leaflets go, but they are somewhat wider in proportion to their length. The main difference is in the varying width of the leaflets and the greater number of nerves. Heer's plant has commonly only 4 nerves, and at most only 6, and the leaflets are very uniform in width. It is very near to *P. Brongniarti*, differing from it only in the shorter leaflets. *P. Brongniarti* shows the same nervation and variability in the width of the leaflets. The plant now in question, in the form of its leaflets, looks something like *Zamites montanensis*, which I described from the Great Falls flora, but is clearly quite different from that."—L. F. W.

[a] See footnote to p. 96. Professor Fontaine in his final report identified this plant with that of Yokoyama, but as Yokoyama's name was preoccupied that of Professor Fontaine becomes the name of the species. Though published the same year it must have antedated Yokoyama's name by several months, but as Diller and Stanton did not publish Professor Fontaine's description, which they had before them, his name would have had to give way to Yokoyama's if that had not been preoccupied. As it is, Fontaine's name may remain, and as he now refers the plant to the genus Nilsonia, the above combination is virtually his.—L. F. W.

NILSONIA? SAMBUCENSIS Ward n. sp.[a]

Pl. LXVII, Fig. 8.

In the collections from the Shasta group of California several imprints of a plant were found whose character is doubtful. It seems to be most like a Nilsonia. The imprints are in the form of segments that are detached from the midrib. Fragments detached in a similar manner were common in the case of *N. schaumburgensis* (Dunk.) Nath., which is an abundant plant in the Geyser beds (see p. 308). The specimen represented in Pl. LXVII, Fig. 8, is one of these segments. It is wider and longer than the segments of *N. schaumburgensis*, being 2 cm. wide and 15 mm. long. The nerves are fine, numerous, and closely placed. They are, as in Nilsonia, single and parallel. The material is too scanty and imperfect to permit the positive determination of this fossil. It may be a large form of *N. schaumburgensis*, for the specimens of this plant from the Geyser strata show some forms that are larger than any hitherto described. It is, except in size, exactly like some of the detached segments of the Geyser fossils.

The plant occurs at localities Nos. 9, 18, and 19.

Genus PTEROPHYLLUM Brongniart.

PTEROPHYLLUM? LOWRYANUM Ward n. sp.[b]

Pl. LXVII, Fig. 9.

A fragment of a detached leaflet of what seems to have been a very large Pterophyllum was found at locality No. 19. As the base of the leaflet was not seen the determination of this fossil can not be positive. As, however, it agrees well with Pterophyllum, I place it provisionally in that genus. The terminal portion is well preserved and has the character given in Fig. 38. The portion obtained is 4 cm. wide in its widest part and 115 mm. long, and this is clearly only a portion of the original leaflet. It is ensiform in shape, with the anterior margin nearly straight and the posterior rounded off in an elliptical manner so that the tip is subacute. The nerves are very slender, parallel, and unbranched

[a] Professor Fontaine assigned no specific name to this species. It seems best to have it bear one, and the one chosen relates to Elder Creek, on which the specimen figured and several others were found.—L. F. W.

[b] The specific name given by Professor Fontaine to this plant had been twice used by others for different species. I name it for Lowry, at which place it was found.—L. F. W.

in all the portions seen. They are remote, being 1 mm. apart. Most of them terminate in the posterior margin of the leaflet. Although this may not be a Pterophyllum, it is clearly a species distinct from the other plants found in the Shasta group, and different from any Pterophyllum hitherto found in the Lower Cretaceous or Neocomian formations. It reminds one strongly of the great Pterophylla of the Rajmahal group of India. Among previously described plants of the Lower Cretaceous, it is most like *Podozamites grandifolius* Font., of the Lower Potomac of Virginia,[a] which is itself a plant not positively determined. The nerves, however, of the Shasta fossil are much more slender than those of the Virginia plant and do not run so far parallel to the margin of the leaflet. In this plant they run, with the exception of those near the anterior margin, straight to the posterior margin, and terminate in it. It is to be regretted that more of this fine plant was not obtained.

Genus CTENOPHYLLUM Schimper.

CTENOPHYLLUM LATIFOLIUM Fontaine?

Pl. LXVII, Fig. 10.

1889. *Ctenophyllum latifolium* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 175, pl. lxviii, figs. 2, 2a, 3.

One specimen was found at locality No. 17 that resembles *Ctenophyllum latifolium* of the Lower Potomac of Viriginia. The specimen consists of fragments of three leaflets, with their bases and terminal portions not shown. The largest portion preserved of one of these has a length of 11 cm., but it was originally much longer. Judging from the parts preserved the leaflets were 27 mm. wide. They are strap shaped. The nerves are parallel and unbranched. They are strong and rather more than 1 mm. apart. As the attachment of these leaflets was not seen the plant may really be a large Pterophyllum of the type of those characteristic of the Rajmahal group of India. However, as the specimen now stands it strongly reminds one of the fine plant *C. latifolium* Font., of the Lower Potomac of Virginia. If several leaflets of that plant had been preserved in their middle parts only and placed in a parallel position they would have left imprints on the stone just like those shown in the California fossil.

[a] Monogr. U. S. Geol. Surv., Vol. XV, p. 180, pl. lxxxii, fig. 2; pl. lxxxiii, fig. 5.

Genus ZAMITES Brongniart.

ZAMITES ARCTICUS Göppert.

Pl. LXVIII, Fig. 1.

1864. *Zamites arcticus* Göpp.: Jahresber. d. Schles. Ges. f. Vaterl. Cult., 1863, p. 84 (nomen).

1866. *Zamites arcticus* Göpp.: Neues Jahrb. f. Min., etc., 1866, p. 134, pl. ii, figs. 9, 10.

1885. *Zamites* sp. Dn.: Trans. Roy. Soc. Canada, Sect. IV, Vol. III, p. 7, pl. i, fig. 4.

One specimen, which appears to be identical with the widely distributed *Zamites arcticus* Göpp., of the Lower Cretaceous, was found at locality No. 19. This is a fragment of the lower part of a leaf showing several leaflets. Although the fragment is small, and only a single specimen was found, there can be no doubt as to the character of the plant, as this type of fossil has so strongly marked features. It is clearly a Zamites, of the type of *Z. arcticus*. The only question is to which of the several species of this type it belongs. Among the Geyser fossils (see pp. 306–310) are a number of imprints of a Zamites of the *arcticus* type, belonging apparently all to one species, which shows some variability, indicating that several forms hitherto described as different species are really slightly different aspects of *Z. arcticus* Göpp. Dunker has described from the north German Wealden formation[a] a Zamites of this type, which he calls *Pterophyllum Lyellianum*. This seems to be a large form of *Zamites arcticus*. Besides the forms that he recognizes as *Z. arcticus*, Heer has described a small Zamites of this type as *Z. brevipennis*.[b] Sir William Dawson has given, from the Kootanie beds of Canada,[c] two forms of the *arcticus* type. One of these he names *Z. montana*, and the other, depicted in fig. 4, pl. i, he leaves undetermined. Both of these plants, as well as Heer's *Z. brevipennis*, are probably *Z. arcticus*. This is indicated by the varying forms found in the Geyser beds, which yield specimens that agree well with the typical *Z. arcticus* and with Dawson's plants, as well as with *Z. brevipennis*.

The specimen from California, now being described, is exactly like the plant left undescribed by Dawson, but delineated in fig. 4. The

[a] Monogr. d. Norddeutsch. Wealdenbildung, p. 14, pl. vi, figs. 1, 1a, 2.

[b] Flor. Foss. Arct., Vol. III, Pt. II, (Kreide-Flora der Arctischen Zone) p. 67, pl. xv, figs. 8, 9, 10.

[c] On the Mesozoic Floras of the Rocky Mountain Region of Canada: Trans. Roy. Soc. Canada, Sect. IV, Vol. III, p. 7, pl. i, figs. 6, 6a, and fig. 4.

Geyser specimens show that these shorter and broader leaflets may be found on the lower portions of leaves which, higher up, have longer and narrower leaflets that are of the typical form of *Z. arcticus*.

ZAMITES TENUINERVIS Fontaine.

Pl. LXVIII, Figs. 2, 3.

1889. *Zamites tenuinervis* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 171, pl. lxvii, fig. 1; pl. lxix, fig. 2; pl. lxx, fig. 1; pl. lxxv, fig. 3; pl. lxxvi, fig. 7; pl. lxxviii, fig. 6; pl. lxxxiv, fig. 7.

At localities Nos. 1, 9, 12, 18, 19, 20, and 22 a number of fragments occur that strongly suggest identity with *Zamites tenuinervis* Font., one of the most common cycads of the Lower Potomac of Virginia. At locality No. 23 a good specimen was found, that given in Pl. LXVIII, Fig. 2. This shows the basal portion of a detached leaflet, with a good deal of the remainder, but the tip is wanting. All the characteristics of *Z. tenuinervis* except the auriculate base are shown in this specimen, and there is no doubt that it is identical with the Potomac fossil. Some of the supposed fragments of this plant, found elsewhere, have a deceptive appearance of strong nerves, which is caused by stripes of carbonaceous matter that adhere to some of the nerves throughout their length. The specimen shown in Pl. LXVIII, Fig. 3, is from locality No. 12.

Genus CYCADEOSPERMUM Saporta.

CYCADEOSPERMUM CALIFORNICUM Fontaine n. sp.

Pl. LXVIII, Fig. 4.

A single specimen of a nut-like seed was found at locality No. 19. It seems to have been of a hard consistency, with a smooth surface. It stands out prominently from the rock. It is ovate-elliptical in form, 2 mm. wide in the widest portion, and 7 mm. long. It tapers to an acute point and has obscure striæ on its surface, which can be seen only with a lens. It seems to be a new species, but this may not be the case, as seeds of this nature do not usually have points of character sufficient positively to determine their true position. This is the only seed thus far found in these collections of fossils from the Shasta group.

Order PINALES.

Family TAXACEÆ.

Genus CEPHALOTAXOPSIS Fontaine.

Cephalotaxopsis ramosa Fontaine. ?

Pl. LXVIII, Figs. 5–7.

1889. *Cephalotaxopsis ramosa* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 237, pl. civ, figs. 2, 3; pl. cvi, figs. 2, 4, 4a; pl. cvii, fig. 3; pl. cviii, fig. 2.

1894. *Cephalotaxopsis magnifolia* Font.? in Diller & Stanton: Bull.Geol. Soc. Am., Vol. V, p. 450. (Pl. LXVIII, Fig. 7.)

Some very imperfect specimens of a plant with narrow, rigid, and short leaves, which narrow gradually toward their bases and tips, were found at localities Nos. 13, 14, and 17. With one exception all the specimens show only portions of detached leaves. The exception is the form depicted in Pl. LXVIII, Fig. 5. This specimen is a portion of a stout twig, with the remains of several leaves that are still attached to it. The narrowness of these leaves and their gradual tapering toward their bases strongly indicate that this fossil is identical with *Cephalotaxopsis ramosa* Font., a plant of the lower Potomac of Virginia. The amount of material is, however, too small and too imperfect to permit a positive determination of the specific character of the plant. It clearly has the character of Cephalotaxopsis and is different from the other plants yielded by the Shasta group.

Pl. LXVIII, Fig. 6, represents the terminal portion of a leaf, which is the widest one found, and Fig. 7 is the small leaf formerly referred with doubt to *C. magnifolia*.

Cephalotaxopsis ? rhytidodes Ward n. sp.

Pl. LXVIII, Fig. 8.

1894. *Cephalotaxopsis* sp.? Font. in Diller & Stanton: Bull. Geol. Soc. Am., Vol. V, p. 450.

1895 [1896]. *Cephalotaxopsis* sp. Font. in Stanton: Bull. U. S. Geol. Surv., No. 133, p. 15.

There are several imprints of a Cephalotaxopsis quite different from that identified doubtfully with *C. magnifolia*. The leaflets are seen only in fragments, but enough is shown to make certain that they were

narrower in proportion to their length and longer than those of *C. magnifolia*, and the nerve is decidedly more slender. The most perfect specimen shows a length of the part above the base to the termination of the leaflet that equals 21 mm. The base is not shown, but the leaflet was evidently considerably longer than the portion shown. The width is greatest at the lower end of the leaflets, where they equal $1\frac{1}{2}$ mm. It tapers very gradually to the end, near which it is less than 1 mm. in width, and it ends in an acute tip. It is then certainly not Abietites. The tapering shows that it is not Pinus and not Leptostrobus. It is most probably a new species of Cephalotaxopsis.[a]

Genus NAGEIOPSIS Fontaine.

NAGEIOPSIS LONGIFOLIA Fontaine?

Pl. LXVIII, Figs. 9–12.

1889. *Nageiopsis longifolia* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 195, pl. lxxv, figs. 1, 1a, 1b; pl. lxxvi, figs. 2–6; pl. lxxvii, figs. 1, 2; pl. lxxviii, figs. 1–5; pl. lxxix, fig. 7; pl. lxxxv, figs. 1, 2, 8, 9.

1894. *Angiopteridium strictinerve* Font.? in Diller & Stanton: Bull. Geol. Soc. Am., Vol. V, p. 450. (Pl. LXVIII, Fig. 12.)

1894. *Nageiopsis longifolia* Font.? in Diller & Stanton: Bull. Geol. Soc. Am., Vol. V, p. 450. (Pl. LXVIII, Figs. 9, 10, 11.)

1896. *Angiopteridium strictinerve* Font.? in Stanton: Bull. U. S. Geol. Surv., No. 133, p. 15. (Pl. LXVIII, Fig. 12.)

1895 [1896]. *Nageiopsis longifolia* Font.? in Stanton: Bull. Geol. Surv., No. 133, p. 15. (Pl. LXVIII, Figs. 9, 10, 11.)

The presence of *Nageiopsis longifolia* Font. in the flora of the Shasta formation can not be positively determined from the specimens found.

[a] The above is Professor Fontaine's original description given in his first report, dated February 23, 1894, which was sent to Mr. Diller and Dr. Stanton at that time. The species was named *Cephalotaxopsis sp.?* and only this name was published in their paper. In his final report on the combined collections this specimen was returned among those referred to *Cephalotaxopsis ramosa* Font.? and was drawn as such, but the drawing brought out the fact, which seems to have been overlooked, that, unlike the other specimens, fine transverse wrinkles or striæ pass from the midrib to the margin the whole length of the leaf. I therefore hesitated to include it among the figures of *C. ramosa?*, and took the pains to return the specimen, accompanied by the drawing, to Professor Fontaine and ask him how he would interpret this feature. In his reply dated July 31, 1902, he says:

"I have examined the specimen carefully with a lens. The transverse lines are distinct under the lens, but are of unequal strength and have no definite plan. I think they are shrinkage wrinkles formed on a thick leaf, and that the plant is most probably a Cephalotaxopsis, possibly a new species."

It seems best to regard it as a new species and consider the generic attribution doubtful. The specific name chosen is intended to refer to the wrinkled appearance, while not positively implying that the appearance is due to wrinkling. The specimen was collected at locality No. 9.—L. F. W.

This plant was first found by me in the Lower Potomac beds of Virginia, where it is quite widely diffused. In the Shasta formation a considerable number of fragments of narrow strap-shaped leaflets have been found that strongly resemble those of the Potomac plant. As no entire leaflets were found, and none of the fragments were attached, there is some doubt as to their true place. In no point do they differ from corresponding detached fragments of *Nageiopsis longifolia*. The nerves agree with those of this fossil in being few in number and rather remote. Some of the fragments show the basal part of the leaflet, and this narrows very gradually, in lancet fashion, as is the case with the leaflets of *N. longifolia*.

The specimens occur at localities Nos. 1, 9, 14, 18, 20, and 22, but are nowhere abundant.

NAGEIOPSIS LATIFOLIA Fontaine.?

Pl. LXVIII, Fig. 13.

1889. *Nageiopsis latifolia* Font., Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 198, pl. lxxxii, fig. 3.

1895 [1896]. *Nageiopsis latifolia* Font., in Stanton: Bull. U. S. Geol. Surv., No. 133, p. 22.

One specimen of a fragment of a large leaflet was found near Riddles, Oreg. This is given in Pl. LXVIII, Fig. 13. The fragment shows a considerable portion of the leaflet, with a good deal of one margin preserved. The leaflet seems to have been elliptical in form and of large dimensions, for the base, extremity, and one margin are gone, and yet the width of the part preserved is 35 mm., while its length is 85 mm. It is much like *Nageiopsis latifolia*, a plant of the Lower Potomac of Virginia. Of course with so small an amount of imperfect material it is not possible to positively determine the true position of this plant. The same may be said of the Potomac plant, for the fossils found were not sufficient to fix its place with certainty.

Family PINACEÆ.

Genus ABIETITES Hisinger.

ABIETITES ELLIPTICUS Fontaine.

Pl. LXVIII, Fig. 14.

1889. *Abietites ellipticus* Font., Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 263, pl. cxxxii, figs. 8, 9; pl. cxxxiii, figs. 2–4; pl. clxviii, fig. 8.

1894. *Abietites californicus* Font. in Diller & Stanton: Bull. Geol. Soc. Am., Vol. V, p. 450 (nomen).

Several impressions of cones were found at locality No. 1. They are ovate-elliptical in form, with thin scales, the terminal ones being apparently spatulate in shape. The fossils are so much like *Abietites ellipticus* Font., from the Lower Potomac of Virginia, that there can be hardly any doubt that it is the same species.

Pl. LXVIII, Fig. 14, represents a fragment of a stout twig with a cone attached that now, owing to the fracture of the rock matter occurring through it, is shown in section. This occurs attached on the right side of the twig. There is on the left or opposite side of the same twig a portion of another cone which was evidently originally attached opposite to the cone first mentioned. In the same plane with the attachment of these two cones there is visible on the twig a prominence indicating that a third cone was once present. This, from analogy with the opposite cones first mentioned, probably had one opposite to it, so that the twig bore originally a whorl of four cones.

ABIETITES MACROCARPUS Fontaine.

Pl. LXVIII, Figs. 15, 16.

1889. *Abietites macrocarpus* Font. Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 262, pl. cxxxii, fig. 7.

1894. *Abietites angusticarpus* Font. in Diller & Stanton: Bull. Geol. Soc. Am., Vol. V, p. 450. (Pl. LXVIII, Fig. 15.)

Several specimens of cones were found in the Horsetown beds which appear to be identical with the fossil cone *Abietites macrocarpus*, first described by me from the Lower Potomac beds of Virginia. They appear to have been long and cylindrical in form and to have had numerous thin and closely appressed scales.

The cone represented by Pl. LXVIII, Fig. 15, was found at locality No. 2. It shows a stout axis with only the basal portions of some of the scales preserved. The lower part of the cone is wanting and only the axis of a portion of the upper part is present. The seeds, in part at least, seem to be still present under the bases of the cone scales. They are well shown on the left side of the axis. They are ovate-elliptical in form, narrowing to the apex. The largest, probably because less compressed, is the lowest in position. It is 2.5 mm. wide in its widest portion and 6 mm. long. Another cone found at locality No. 1 and represented in Fig. 16 of the same plate shows more of the original cone. In this the overlapping,

closely appressed scales hide the axis. The upper portion and termination of this cone are preserved, but the basal part is wanting. The part preserved is a little over 2 cm. wide and 52 mm. long. As this is a mere fragment, the original cone must have had a very considerable length.

ABIETITES ? sp. Fontaine (immature cone).

Pl. LXVIII, Fig. 17.

1894. *Abietites ?* sp. Font. in Diller & Stanton: Bull. Geol. Soc. Am., Vol. V, p. 450 (nomen).

A single imprint of what seems to be an immature cone, or partially developed fertile catkin, was found at locality No. 11. It is elongate-elliptical in form and shows the axis with several thin scales attached. It has a length of over 1 cm., with the tip not preserved. This fossil has more of the character of a cone of Abietites than any other conifer, but with so small an amount of imperfect material the precise character can not be determined.

Genus PINUS Linnæus.

PINUS SHASTENSIS Fontaine n. sp.

Pl. LXIX, Figs. 1–3.

A considerable number of specimens of what seems to be a new species of Pinus were found at locality No. 1. This occurs in Shasta County, Cal., 1½ miles north-northeast of Horsetown, and the plants are obtained from typical Horsetown beds, occurring mostly in loose bowlders. Many of the specimens show that the leaves were attached to the stems. Most of the stems that are indicated are bits of twigs that are very stout as compared with the leafy twigs of fossil conifers that are usually found.

The stem shown in Pl. LXIX, Fig. 1, is somewhat compressed by pressure, but still retains nearly its original cylindrical form and is 1 cm. wide. It shows projections more or less cylindrical in shape scattered over the surface. These correspond to the insertions of the leaf bundles. They seem to be a characteristic feature of the stems, for other specimens that are imprints of stems show pittings that correspond to them. The number of leaves in a bundle could not be determined. They show in the best-preserved specimens a single pretty strong nerve, but most of the imprints had evidently been more or less macerated before their entombment in rock material, and some of these give vague indications of there

having been several nerves. There was, however, only one nerve. Most of the impressions of leaves are unusually wide for fossil leaves of Pinus, being not uncommonly 2 mm. wide.

Pl. LXIX, Fig. 1, represents a portion of a somewhat flattened stem, with the projections mentioned before. Fig. 2 depicts a portion of a stem that was larger than that given in Fig. 1. This fragment shows more or less rounded pits, corresponding to the projections of Fig. 1. It also has some fragments of leaves in the position they had when attached to the stem. Fig. 3 represents a fragment of another stout stem. It shows the basal portions of a number of leaves radiating from the stem, some of them being attached to it.

Genus SEQUOIA Endlicher.

SEQUOIA REICHENBACHI (Geinitz) Heer.[a]

Pl. LXIX, Figs. 4, 5.

1842. *Araucarites Reichenbachi* Gein.: Charakteristik d. Schicht. u. Petref. d. Sächs. Kreidebirges, Heft II, p. 98, pl. xxiv, fig. 4.
1846. *Cryptomeria primaeva* Corda in Reuss: Versteinerungen d. böhm. Kreideformation, Abth. II, p. 89, pl. xlviii, figs. 1–11.
1846. *Pinus exogyra* Corda in Reuss: Op. cit., p. 91, pl. xlviii, figs. 16–18.
1847. *Geinitzia cretacea* Endl.: Synopsis Coniferarum, p. 281.
1847. *Pinites exogyrus* (Corda) Endl.: Op. cit., p. 284.
1849. *Araucaria Reichenbachi* (Gein.) Debey: Entwurf z. e. Geogn.-Geogenst. Darstellung d. Gegend v. Aachen (Nachträge), p. 63.
1849. *Cryptomerites primaevus* (Corda) Brongn.: Tableau, p. 74.
1850. *Piceites exogyrus* (Corda) Göpp.: Monogr. Foss. Conif., p. 208.
1853. *Cycadopsis cryptomerioides* Miq.: Verh. d. Geol. Kaart v. Nederl., I. Deel, p. 42 [10], pl. iii.
1863. *Araucarites adpressus* Marck: Palaeontographica, Vol. XI, p. 80, pl. xiii, figs. 10, 11.
1867. *Cunninghamites Sternbergii* Ett. (excl. syn.): Sitzb. Wien Akad., Vol. LIV, Abth. I, p. 246, pl. i, figs. 4–6.
1868. *Sequoia Reichenbachi* (Gein.) Heer: Fl. Foss. Arct., Vol. I, p. 83, pl. xliii, figs. 1d, 2b, 5a, 8, 8b.

[a] I omit from the synonymy of this species the *Conites familiaris* Sternb, a Cenomanian cone from Bohemia, the *Bergeria minuta* Presl, which is perhaps not the same as the *Cunninghamites Sternbergii* Ett., but probably belongs to Sequoia, and the *Sedites? Rabenhorstii* Gein., a twig of doubtful affinity, all of which have been referred by different authors to *Sequoia Reichenbachi*, but none of which certainly belong there, and the names of which all antedate the *Araucarites Reichenbachi* of Geinitz, so that their positive acceptance would involve a change in the name of this well-known species. Such a change should be made only upon a certainty.—L. F. W.

A considerable number of specimens of a conifer that is probably *Sequoia Reichenbachi* were found at localities Nos. 1, 16, and 17. They are most numerous at locality No. 1. They are all imperfectly preserved and consist of small fragments of branches. Some of them show a diameter of 5 mm. The leaves have the character of those of *S. Reichenbachi*. They are comparatively long and are widest at base and decurrent. They have a midrib and narrow gradually to their tips. They are also curved inward toward the stem.

Pl. LXIX, Figs. 4 and 5, represent portions of such leafy branches. Fig. 5 delineates a very slender twig.

SEQUOIA AMBIGUA Heer.

Pl. LXIX, Fig. 6.

1874. *Sequoia ambigua* Heer: Fl. Foss. Arct., Vol. III, Pt. II (Kreide-Flora der Arctischen Zone), p. 78, pl. xxi, figs. 1, 2a, 3–8, 9a, 10a,b,c.

Sequoia ambigua Heer was found in a considerable number of specimens. It occurs at localities Nos. 1, 16, and 17. It is most abundant at locality No. 1. All the specimens consist of fragments of ultimate twigs, containing some leaves. One of the imprints shows at the summit of the twig traces of a cone. The specimens are not very well preserved, but show the characteristic features of *S. ambigua* with sufficient clearness to render it certain that this conifer exists in the Horsetown beds.

Pl. LXIX, Fig. 6, represents a fragment of a stout twig, with some of the leaves well preserved.

Genus SPHENOLEPIDIUM Heer.

SPHENOLEPIDIUM STERNBERGIANUM (Dunker) Heer.

Pl. LXIX, Fig. 7.

1846. *Muscites Sternbergianus* Dunk.: Monogr. d. Norddeutsch. Wealdenbildung, p. 20, pl. vii, fig. 10.
1849. *Juniperites Sternbergianus* (Dunk.) Brongn.: Tableau, p. 108.
1852. *Araucarites Dunkeri* Ett. in pt.: Abh. d. k. k. Geol. Reichsanst., Vol. I, Abth. III, No. 2, p. 27, pl. ii, figs. 2, 3, 7, 8.
1870. *Widdringtonites Dunkeri* (Ett.) Schimp.: Pal. Vég., Vol. II, p. 329.
1871. *Sphenolepis Sternbergiana* (Dunk.) Schenk: Palaeontographica, Vol. XIX, p. 243 [41], pl. xxxvii [xvi], figs. 3, 4; pl. xxxviii [xvii], figs. 3–13.
1881. *Sphenolepidium Sternbergianum* (Dunk.) Heer: Fl. Foss. du Portugal, p. 19, pl. xiii, figs. 1a, 2–7, 8b, pl. xiv.

Four specimens of a conifer that agrees exactly with *Sphenolepidium Sternbergianum* (Dunk.) Heer were found at locality No. 17, which is probably in the lower part of the Horsetown beds.

The most complete specimen is that given in Pl. LXIX, Fig. 7. It represents a small portion of a penultimate branch, with a part of an ultimate twig attached. The ultimate twig is pretty well preserved and, with the help of a lens, shows quite distinctly the characteristic leaves of *S. Sternbergianum*. It seems to have been rare.

Class ANGIOSPERMÆ.

Subclass DICOTYLEDONES.

Order SALICALES.

Family SALICACEÆ.

Genus SALICIPHYLLUM Conwentz.[a]

Saliciphyllum pachyphyllum Fontaine n. sp.

Pl. LXIX, Fig. 8.

A single specimen of a leaf resembling a Salix was found at locality No. 23 in the same beds with the Menispermites described below. The specimen shows a nearly entire leaf. It is of small size and broadly elliptical in shape, narrowing gradually to the base and apex. The midnerve is distinct and strong, but no other nerves are visible. The texture of this seems to have been leathery and remarkably thick. It is probably owing to this dense consistency that no subordinate nervation is shown. The plant seems to be a new species. In some points

[a] It is necessary to credit this name—it can not be called a genus—to Conwentz, who, in 1886, described it as follows: "Novum genus omnia folia fossilia salicibus recentibus simillima amplectens" (Die Flora des Bernsteins, etc., von H. R. Göppert und A. Menge, nach deren Hinscheiden selbständig bearbeitet und fortgesetzt von H. Conwentz, zweiter Band, Danzig, 1886, p. 43), and fully treated one species, *S. succinenum* Conw. Three years later appeared Professor Fontaine's Potomac Flora, in which, p. 302, he describes Saliciphyllum as a new genus. Although he gives it a definite character as "leaves . . . elongate-elliptical in outline, with midnerves strong at base and much attenuated toward the summit; lateral nerves slender, the primaries going off very obliquely and curving strongly toward the summit of the leaf, continuing approximately parallel with the margin, but gradually approaching it;" still he says that "in the nervation, so far as it could be made out, and in the shape of the leaves, they appear to be nearer Salix than any other genus," and it is evident that his idea was practically the same as that of Conwentz, viz, to group together all the leaves that closely resembled those of the living willows. If it were necessary to regard Fontaine's genus as distinct from that of Conwentz it would also be necessary to rename it, and rather than do this it seems better to retain the name and credit it to the author who first used it.—L. F. W.

it is much like *Saliciphyllum ellipticum* Font.[a] of the Lower Potomac of Virginia. It may be the same species, but it widens more suddenly and decidedly in its widest portion than do any of the Potomac leaves.

SALICIPHYLLUM CALIFORNICUM Fontaine n. sp.

Pl. LXIX, Fig. 9.

Another Salix-like leaf was found associated with *Saliciphyllum pachyphyllum* at locality No. 23, which, however, is obviously different from it. This, too, shows only one imprint, but the reverse was obtained in this case. Nearly the whole leaf is preserved. It is oblong in form, with the base and summit not preserved, so that the exact shape of the entire leaf can not be made out. It shows a slender but distinct midrib and no other nerves. It is apparently a new species, and, like *S. pachyphyllum*, has a recent aspect. The texture indicates a leaf decidedly thinner than *S. pachyphyllum*.

Genus POPULUS Linnæus.

POPULUS ? RICEI Fontaine n. sp.

Pl. LXIX, Fig. 10.

This is shown in only one specimen. It is the lower part of a dicotyledonous leaf of small size with a thick texture. Its exact place can not be determined from this small amount of material. As its facies is that of Populus it is placed doubtfully in that genus. The specific name is derived from Mr. Claude Rice, its discoverer.

The texture of the leaf is so thick that the secondary nervation is not visible. Only the midrib and petiole can be seen. The basal portion of the leaf is well preserved, showing distinctly its shape, with the midrib and a portion of the petiole. The latter is curved, probably as an accident in preservation. The midrib is strong, but flat. The leaf narrows to a wedge shape at its base.

This specimen was found by Mr. Claude Rice in the Cow Creek Valley, on Wilson Creek, 25 miles southeast of Buck Mountain in Oregon. It occurs in a fine-grained gray sandstone, which is of Horsetown age, as is shown by the shells that the rock contains.

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[a] Monogr. U. S. Geol. Surv., Vol. XV, p. 303, pl. cxlvi, figs. 2, 4; pl. cl, fig. 8; pl. clxiii, fig. 5; pl. clxvii, fig. 2.

Order PROTEALES.

Family PROTEACEÆ.

Genus PROTEÆPHYLLUM Fontaine.

PROTEÆPHYLLUM CALIFORNICUM Fontaine n. sp.

Pl. LXIX, Fig. 11.

Two specimens of what seems to be an archaic form of dicotyledon were found at locality No. 18, in the upper part of the Knoxville or Aucella beds. The specimens are small fragments which are not sufficient to give any idea of the form, size, and shape of the leaf of which they are a part.

The fragment shown in Pl. LXIX, Fig. 11, seems to have come from the margin of the leaf. It shows a principal nerve, probably not principal of the leaf, which seems to have run, in the part displayed, parallel with the margin of the leaf. This nerve sends off branches nearly or quite at right angles with itself, and bends sharply at the point where the branch is given off, so that it is flexuous in its course. In the specimen figured these nerves in most cases make angles somewhat greater than right angles with the principal, but this seems due to a slight distortion, for in the other specimen they go off at right angles. The nerves of the second order on the specimen seem to have united to form loose or straggling and irregularly shaped quadratic meshes. This sort of nervation is similar to that of the old types of dicotyledons found by me in the lowest Potomac beds of Virginia,[a] which were grouped under the generic name Proteæphyllum. At the same time it should be stated that this type of leaf is much like the forms called Dictyophyllum by some authorities. These are, in my opinion, archaic and synthetic types of dicotyledons. Schenk has described a leaf of this type[b] from the Wealden of Hanover with the name *Dictyophyllum Roemeri*.

There is not enough material to determine positively whether or not this California plant is a new species. It is quite possible that it may be identical with some of the Potomac forms.

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[a] Monogr. U. S. Geol. Surv., Vol. XV, pp. 281–282.

[b] Die Foss. Flor. der Nordwestdeutsch. Wealdenform., p. 22, pl. x, fig. 3 (Palaeontographica, Vol. XIX, p. 224, pl. xxxi, fig. 3).

Order RANALES.

Family MENISPERMACEÆ.

Genus MENISPERMITES Lesquereux.

MENISPERMITES CALIFORNICUS Fontaine n. sp.

Pl. LXIX, Figs. 12–14.

Several specimens of what appears to be a new species of Menispermites were found at locality No. 23 in what is probably the top of the Horsetown beds. The specimens are all small fragments of leaves that do not suffice to show the shape and size of the leaves to which they belonged. They evidently came from leaves of different sizes and possibly from two different species of Menispermites. The nervation, however, is so markedly like that of the genus that there can be little doubt that it is present.

Pl. LXIX, Fig. 12, represents what appears to be the basal portion of a small leaf. This shows a main nerve from which, near its base, two subordinate nerves go off opposite each other. From these last minor nerves go off nearly at right angles and unite to form irregular quadrangular meshes. Fig. 13 gives a fragment of what must have been a rather large leaf, possibly of a different species from that represented by Fig. 12. There is in this fragment a principal nerve from which subordinate nerves go off, and these send off minor nerves, as in Fig. 12. But the ultimate nerves in the fragment depicted in Fig. 13 are much slenderer than those of that shown in Fig. 12. Probably the reason is the fact that the latter fragment comes from the basal portion of a leaf. Fig. 14 depicts a fragment of a leaf showing the characteristic dichotomous forking of the terminal portion of one of the principal nerves.

Order SAPINDALES.

Family SAPINDACEÆ.

Genus SAPINDOPSIS Fontaine.

SAPINDOPSIS OREGONENSIS Fontaine n. sp.

Pl. LXIX, Figs. 15–17.

Two specimens of what seems to be the same species of dicotyledon were obtained from Oregon.

The one represented in Pl. LXIX, Figs. 15 and 16 (counterparts), shows the basal portion and petiole, while the specimen Fig. 17 gives the upper part of the same kind of leaf. The leaf shown in Figs. 15 and 16 was collected by Will Q. Brown at the locality that yielded the *Dioonites Buchianus abietinus* and in the same sandstone. The specimen shown in Fig. 17 was collected by Mr. Claude Rice from a locality given as "near Riddles, Oreg., Horsetown beds." The rock material containing both imprints is exactly alike, and it is probably the same stratum, although this is not stated on the labels. The specimens are evidently parts of the leaves of Sapindopsis, and it may be one of the forms of that genus found in the Lower Potomac of Virginia and Maryland. I am, however, induced to regard it as a new species on account of the length of the petioles, which much surpasses that of any of the previously described species. The species of the Lower Potomac have the uppermost leaflets of the compound leaf consolidated. Lower down they are sessile, and in the lowest ones a very short petiole is shown. It may be that in leaflets lower than any found in the Potomac species the petiole becomes as long as that of the Oregon plant. It is noteworthy that the Potomac compound leaves preserved in the fossil state show only the leaflets toward the end of the compound leaf. The leaf texture of *Sapindopsis oregonensis* is so thick and coriaceous that the surface is smooth and shining, while the secondary nervation is hidden. The midrib, however, is strong. The leaflet was narrowly elliptical in form and probably 6 cm. long, with a width in the widest part of 12 mm.

Order ROSALES.

Family CÆSALPINIACEÆ.

Genus ACACIÆPHYLLUM Fontaine.

ACACIÆPHYLLUM ELLIPTICUM Fontaine n. sp.

Pl. LXIX, Fig. 18.

Two leaves were found in the Shasta formation that strongly resemble those from the Lower Potomac strata of Viriginia which have been described by me[a] under the generic name Acaciæphyllum. One

[a] Monogr. U. S. Geol. Surv., Vol. XV, p. 279.

of these, for which the specific name *ellipticum* is proposed, was found in a single specimen at locality No. 4 in the Horsetown beds. This shows the entire leaf, with the exception of the extreme tip. It is small and elliptical in form. It is inequilateral at base, the midrib being there closer to the margin on one side than on the other. The texture of the leaf is thick and firm. A slender midnerve is shown, but the other nervation is indistinct. There are traces of slender nerves that are sent off under a very acute angle and are directed toward the tip of the leaf, as in the Potomac Acaciæphyllum.

ACACIÆPHYLLUM PACHYPHYLLUM Fontaine n. sp.

Pl. LXIX, Fig. 19.

The impression, with its reverse, of a small leaf was found at locality No. 19, in the Knoxville beds. This leaf is remarkably thick and leathery, so as to obscure all its nervation, even the midrib. This thick character, its shape, and its small size make the imprint left by it resemble somewhat that of a nut. It is broadly elliptical in form, with the full width maintained nearly to its tip, where it is very obtusely rounded off. It is narrowed gradually to its base, so that it tends to a spatulate form. The midrib is apparently very slender and is not distinctly shown. No other nervation is visible. In form this leaf very much resembles *Acaciæphyllum spatulatum* Font., of the Potomac beds,[a] but although the texture of that plant is thick, as is characteristic of the Acaciæphylla, that of the plant now in question is decidedly thicker.

GENERAL REMARKS AND CONCLUSIONS.

This completes the description of all the identifiable plants found in the collections made in the Shasta formation of California and Oregon. The following lists give these plants arranged according to the divisions of the Shasta and Chico formations in which they occur. This grouping will serve to show the distribution of the plants in the formations, and will indicate any changes that took place in ascending from the Knoxville through the Horsetown beds to the base of the Chico, the lower member of the Upper Cretaceous. A reference to the list of localities, with their geological horizons, will show that Nos. 2, 8, and 21 are given as belonging

[a] Monogr. U. S. Geol. Surv., Vol. XV, p. 280, pl. cxxxviii, figs. 4, 6–9.

to the base of the Chico. Very few plants come from them. The plants described in this paper, or rather the different specimens, ascribed to various genera and species, have very different values for throwing light on the character of the flora. Some of the specimens can be positively determined, others are of very doubtful character, and their assignment to this or that species or genus means simply that the specimen is more like the form with which it is identified than any other. I will try to indicate in the lists the degree of positiveness with which the determination of a given plant, assigned to this or that horizon, has been made.[a]

Plants occurring in the Shasta or Lower Cretaceous beds.

I. In the Knoxville or lower member only:

1. Dicksonia pachyphylla Font. n. sp. Only one doubtful specimen.
2. Thyrsopteris rarinervis Font.? Few and very doubtful fragments.
3. Cladophlebis parva Font. Imperfect specimens.
4. Cladophlebis falcata Font. Numerous, and some fine specimens.
5. Cladophlebis Ungeri (Dunk.) Ward n. comb. Two very small fragments.
6. Gleichenia Nordenskiöldi Heer? Doubtful specimens.
7. Sagenopteris Mantelli (Dunk.) Schenk. Good specimens.
8. Hausmannia? californica Font. n. sp. Only one very doubtful specimen.
9. Cladophlebis alata Font.? Doubtful specimens.
10. Equisetum texense Font.? Very doubtful specimen.
11. Nilsonia Stantoni Font. n. sp. Fairly good specimen.
12. Nilsonia californica Font. A single but very good specimen.
13. Nilsonia? sambucensis Ward n. sp. A few doubtful fragments.
14. Pterophyllum? lowryanum Ward n. sp. One very doubtful specimen.
15. Zamites arcticus Göpp. Only one, but a distinct specimen.
16. Cycadeospernum californicum Font. n. sp. A single but very distinct specimen.
17. Cephalotaxopsis? rhytidodes Ward n. sp. Several specimens.
18. Abietites? sp. Font. immature cone. A single specimen of doubtful character.
19. Proteæphyllum californicum Font. n. sp. A single and doubtful specimen.
20. Acaciæphyllum pachyphyllum Font. n. sp. A single but distinct specimen.

[a] The following four species are not included in Professor Fontaine's discussion, having, except in one case, been sent to him since his report was received:

1. *Gleichenia Gilbert-Thompsoni* Font. n. sp. (see p. 232). It comes apparently from the extreme upper Horsetown beds; perhaps from the base of the Chico.

2. *Dioonites Buchianus rarinervis* Font.? This was included in his first report, from which the description is taken, and the name published by Diller and Stanton. It is a small piece of a leaf on the same stone with the immature cone of Abietites, and was overlooked in the final report. It comes from the Knoxville beds.

3. *Populus? Ricei* Font. n. sp. This certainly comes from the Horsetown beds.

4. *Sapindopsis oregonensis* Font. n. sp. This is also from the Horsetown beds.—L. F. W.

II. In the Horsetown or upper member only:

1. Sagenopteris oregonensis Font. n. comb. Two good specimens and one doubtful one.

2. Ctenopteris integrifolia Font.? Two very imperfect specimens.

3. Dioonites Dunkerianus (Göpp.) Miq. Several fair specimens.

4. Ctenophyllum latifolium Font.? One imperfect specimen.

5. Nageiopsis latifolia Font.? A single doubtful specimen.

6. Abietites ellipticus Font. Several very distinct specimens.

7. Abietites macrocarpus Font. Several imperfect specimens.

8. Pinus shastensis Font. n. sp. A considerable number of specimens, some quite good.

9. Sequoia Reichenbachi (Gein.) Heer. Several distinct specimens and a large number of doubtful ones.

10. Sequoia ambigua Heer. A considerable number of undoubted specimens.

11. Sphenolepidium Sternbergianum (Dunk.) Heer. Four quite distinct specimens.

12. Saliciphyllum pachyphyllum Font. n. sp. Only one, but a good specimen.

13. Saliciphyllum californicum Font. n. sp. Only one, but a very good specimen.

14. Menispermites californicus Font. n. sp. Several very imperfect specimens.

15. Acaciæphyllum ellipticum Font. n. sp. Only one, but a good specimen.

III. In both Knoxville and Horsetown beds:

1. Sagenopteris nervosa Font. n. sp. A considerable number of specimens, several quite good.

2. Angiopteridium canmorense Dn.? A good many specimens, but all imperfect.

3. Angiopteridium strictinerve Font. Numerous fragments, some quite distinct.

4. Angiopteridium strictinerve latifolium Font. A number of small fragments, mostly quite poor.

5. Dioonites Buchianus (Ett.) Born. Good and undoubted specimens occur only in basal Horsetown beds. Doubtful fragments occur on other horizons of the Horsetown and in the Knoxville beds.

6. Dioonites Buchianus abietinus (Font.) Ward. Several undoubted specimens were found only in the basal Horsetown beds. Doubtful fragments only were found in the Knoxville beds.

7. Zamites tenuinervis Font. Doubtful fragments occur in the Knoxville and Horsetown strata, and one good leaf in the upper Horsetown beds.

8. Cephalotaxopsis ramosa Font.? A few quite perfect fragments.

9. Nageiopsis longifolia Font.? All are doubtful fragments, which, in the Knoxville beds, are not rare. Only one in the Horsetown beds.

IV. In Knoxville, Horsetown, and base of the Chico:

1. Cladophlebis Browniana (Dunk.) Sew. Numerous imperfect fragments, which are most common in the Knoxville beds.

2. Sagenopteris elliptica Font. Several fair specimens. Those in the Knoxville occur in the upper beds.

V. In the Knoxville and the base of the Chico:

Matonidium Althausii (Dunk.) Ward. Two very imperfect fragments, one in each formation.

It will be noticed that these plants indicate decidedly a Lower Cretaceous age for the Shasta formation. The plants that have been hitherto recognized in other regions occur in widely separated formations of that age, such as the Wealden of northern Europe, the Neocomian of Japan, the Lower Potomac, the Comanche, and the Great Falls beds. In the Knoxville the flora has an older character than that of the Horsetown, at least in the greater deficiency of younger elements, such as the dicotyledons. All the dicotyledons of modern aspect occur in the upper part of the Horsetown beds. These are, it is true, very few in number, and imperfectly made known by the specimens obtained, but they suggest the idea that the upper Horsetown beds are of about the same age as the Aquia Creek beds of the Lower Potomac of Virginia and Maryland, as limited by Professor Ward. The Knoxville and the lower portion of the Horsetown strata have a flora more like that of the James River or lowest member of the Potomac of Virginia. The few plants from the base of the Chico do not indicate any marked change from the Shasta flora, but they do not suffice to give the character of the flora of the basal Chico beds.

CYCADEAN TRUNKS FROM THE SHASTA FORMATION.

Fossil cycadean trunks have been found in the Mesozoic beds of the United States at many points east of the Rocky Mountains and on their eastern slopes, viz, in the States of Maryland, Kansas, Colorado, South Dakota, and Wyoming, but until lately their occurrence on the Pacific slope had not been reported. On September 19, 1900, Dr. T. W. Stanton obtained a fine and nearly perfect trunk in California. The conditions under which this trunk was secured are set forth in the following note which Doctor Stanton kindly furnished me at the time he turned over the specimen, on November 14 of that year:

The cycad from Colusa County, Cal., was found on the ranch of Mr. B. P. Pryor, in the valley of Grapevine Creek, about 6 miles west of Sites, on the road to Stony Ford. The specimen was in the front yard at the ranch house and Mr. Pryor says

it was there when he moved to the place several years ago, the previous occupant of the house having been his uncle. He is confident that it was picked up in the field near by, and he showed me another cycad fragment, badly weathered, that had evidently formed part of a large specimen, stating that he himself had found this specimen in his plowed field. There were also fragments of rock with lower Chico invertebrates that had been picked up in the same field, and he directed me to a locality near by, on beds whose strike would carry them up the valley through this field, where Chico fossils were found in place.

The valley of Grapevine Creek is here not more than one-fourth to one-half mile wide and nearly parallel with the north-south strike of the strata exposed in high ridges on either side. A short distance up the creek (south), however, its course changes so that its source is some miles to the westward, and it probably crosses both Knoxville and Horsetown beds, though no direct paleontologic proof of this was found. Assuming that the cycad was brought to Pryor's field a greater or less distance by Grapevine Creek, the possible sources of the specimen seem to be limited to the Knoxville, the Horsetown, and the lower Chico, with the probabilities in favor of one of the two last named.

From the above there seems to be some doubt whether the specimen really came from the Shasta formation or from the overlying Chico, but the probabilities are so largely in favor of the Horsetown age of the beds containing it that it is tolerably safe to treat it under this head.

The trunk certainly belongs to the genus Cycadeoidea as this genus has been delimited in my previous papers.[a] It is of about the average size of those found in the Potomac formation of Maryland and the Lakota formation of the Black Hills. Although much compressed laterally, the shape is ovate or subconical, tapering uniformly from base to near the summit, where it is rounded off. It is much more flattened above than below, and the compression has been chiefly on one side, where the scars are distorted, and above the middle there is a deep and large circular depression, as if a stone had lain upon that part and forced the surface inward. This pressure seems also to have come more from above, so as to make the scars downwardly appressed. The upper edge is thin and a small triangular piece has been broken out of it a little one side of where the axis comes through. There is no distinct terminal bud, but neither is there any depression caused by the loss of the apical leaves. The base is very even and smooth, looking almost as if it had been ground.

[a] Proc. Biol. Soc. Washington, Vol. IX, April 9, 1894, p. 79; Vol. XI, March 31, 1897, pp. 6–9; Proc. U. S Nat. Mus., Vol. XXI, 1898, pp. 196–229; Nineteenth Ann. Rep. U. S. Geol. Surv., Pt. II, 1899, pp. 598–602

The central part of the medulla has decayed out, leaving a deep cavity or hollow 7 cm. deep and 6 by 10 cm. in diameter. The whole interior seems to be pure silica, and strong hydrochloric acid produced no reaction when applied to the fracture at the summit or to the smooth base, but over the rest of the surface there was a calcareous wash without appreciable thickness, and when immersed in an acid bath it was removed without materially altering the tissues or changing the color.

The trunk stands 23 cm. high, and the diameters at the base are 17 cm. and 34 cm., respectively, giving a girth of 86 cm. About midway of the trunk the girth is reduced to 78 cm., and near the summit to 60 cm. Here it is much more flattened, the minor diameter being only 5 cm. It weighs 58.47 kg. The remaining characters are specific and will be described as such.

The genus Cycadeoidea has been referred to an order distinct from the Cycadales and called the Bennettitales, and to a family distinct from the Cycadaceæ, called the Bennettitaceæ. The reproductive organs, according to Solms-Laubach, indicate a less advanced type of vegetation than the living Cycadaceæ,[a] and they should therefore precede the latter in the ascending order according to the classification of Engler and Prantl adopted in this paper. It should, however, be remarked that the reference of the leaf impressions of cycadaceous fossil plants to the Cycadaceæ is made on account of our ignorance of their true systematic position, as no reproductive organs are found attached to them. It is altogether probable that the trunk here described bore the leaves of some of the genera found in the same beds, but it is impossible to determine which one of them. It will probably prove, should the connection ever be made, that nearly all Mesozoic genera of cycads really belong to the Bennettitales.

I am unable to refer the present trunk to any of the species of Cycadeoidea hitherto described, and am therefore obliged to regard it as forming a new species. I name the species after its discoverer, Dr. T. W. Stanton.

[a] Mr. Worsdell has come to the contrary conclusion, but upon evidence which, so far as I am capable of weighing it, is not satisfactory. The affinities of the Mesozoic fossil *Bennettites Gibsonianus* Carr., by W. C. Worsdell. Annals of Botany, Vol. XIV, No. 56, December, 1900, pp. 717–721.

Genus CYCADEOIDEA Buckland.

Cycadeoidea Stantoni Ward n. sp.

Pl. LXX.

Trunk of medium size (23 cm. high, 17 by 34 cm. in diameter), conical, much compressed laterally, unbranched, of a light-gray or ash color, firmly silicified, fine grained, rather hard, and of a medium specific gravity; organs of the armor horizontal, except near the summit, where they are increasingly ascending, becoming vertical at the apex; leaf scars forming two distinct series of spiral rows around the trunk, those from left to right forming an angle of 30° and those from right to left an angle of 45° with the axis; scars subrhombic, large, and well developed, 3 cm. wide, 5–15 mm. high; leaf bases hard, firm, and fine grained, not porous, their summits sometimes 15 mm. below the surface, sometimes rising 1 cm. above it, but in most cases nearly on a level with it, usually rounded and convex, occasionally broken across, showing a smooth fracture, but more frequently scaled away so as to show an outer layer and a circle of protuberances, which consists of the scars of the vascular bundles, a second circle of bundles occurring farther inward, and scattered ones near the center; ramentaceous walls 5 mm. to 1 cm. thick, hard and firm, presenting a creased and plaited appearance with sharp ridges and interrupted grooves, the middle groove representing the union of the contiguous plates; reproductive organs not prominent, very anomalous, perhaps mostly abortive, very numerous, occupying all the interspaces among the leaf scars, very small and indefinite in shape, and only represented by clusters of large and deep pits which fill the angles and occur between the walls of the leaf scars; most of these pits apparently scars of the involucral scales which have disappeared, subtriangular, subrhombic, or somewhat crescent-shaped, 4 mm. by 8 mm. in diameter, other more central and circular ones probably representing the essential organs; armor 3 cm. thick on the sides and 7 cm. thick at the ends of the elliptical base, where alone it can be seen, averaging about 5 cm.; woody axis undifferentiated, 6–15 cm. thick, hard and firm; medulla 8 cm. by 12 cm. in diameter, somewhat distinctly separated from the

wood, having a very hard and fine-grained sheath 1–2 cm. thick surrounding the large, coarse-grained, reddish, sandy-appearing interior, which is much decayed and hollowed out in the only specimen known.

Pl. LXX represents the best preserved side of the specimen.

FLORA OF THE KOOTANIE FORMATION.

The name "Kootanie series" was first used by Dr. George M. Dawson in some notes furnished by him to his father, Sir William Dawson, in 1885, based on field explorations made in 1884 in the Rocky Mountain region of Alberta, north of the forty-ninth parallel, in the course of which collections were made from various horizons, but then for the first time from beds in the Lower Cretaceous, and it was to these beds that the name was applied. The only fossils found in the beds were remains of plants, of which a considerable collection was made. These plants were determined by Sir William Dawson, and descriptions and figures were embodied in a paper presented by him to the Royal Society of Canada on May 27, 1885, in which were also contained the notes furnished by Doctor Dawson.[a] The principal localities for the plants were Martin Brook, or Martin Creek; North Fork of Old Man River; near Canmore; North Kootanie Pass; entrance to Kootanie Pass; Coal Creek; and Crows Nest Pass. Twenty-two forms are described. Eight of these were new and the other 14 were identified with Lower Cretaceous and Jurassic species previously known, a few of them occurring also in Upper Cretaceous beds.

About the same time, Dr. J. S. Newberry made an examination of the Great Falls coal basin in Montana, but did not succeed in finding any fossils by which its age could be determined. A little later, however, Mr. R. S. Williams, a botanist living at Great Falls, discovered impressions of plants in a railroad cutting 5 miles above the mouth of Sun River, which he sent to Doctor Newberry, who determined them and found among them one of the new species described by Dawson in the paper last mentioned, viz, the *Zamites montana* Dn., also the *Sequoia Smittiana* Heer, a Lower Cretaceous species from Greenland (Kome beds), which was also found in the Kootanie and figured by Dawson.

[a] On the Mesozoic floras of the Rocky Mountain region of Canada, by Sir William Dawson: Trans. Roy. Soc. Canada, Vol. III, Sect. IV, 1885, pp. 1–22, pl. i–iv. The Kootanie is named and described on p. 2 of this paper.

In announcing these results in 1887 Doctor Newberry says:

These plants prove beyond question that the Great Falls coal basin is of the same age with those that have been described north of the boundary line by Dr. George M. Dawson, in what he has designated as the Kootanie series. Judging from the absence of dicotyledonous leaves, this formation, like that of Kome, Greenland, belongs to the lower half of the Cretaceous system, and is older than the Dakota group.[a]

In a paper by Sir William Dawson published in 1888[b] and containing a section designed to show the successive floras and subfloras of the Cretaceous in Canada, he says:

The Kootanie series should probably be placed at the base of the table as a representative of the Urgonian or Neocomian, or, at the very least, should be held as not newer than the Shasta group of the United States geologists, and the Lower Sandstones and Shales of the Queen Charlotte Islands. It would seem to correspond in the character of its fossil plants with the oldest Cretaceous floras recognized in Europe and Asia, and with that of the Kome formation in Greenland, as described by Heer. No similar flora seems yet to have been distinctly recognized in the United States, except, perhaps, that of the beds in Maryland, holding cycads, which were referred many years ago by Tyson to the Wealden.

When the railroad then in construction from Helena to Great Falls reached the latter town, some of the cuttings passed through shales containing lenticular nodules of iron ore which had formed around vegetable matter, and these nodules when broken open often revealed impressions of plants, some of them very clear. Mr. Williams collected some of these and sent them to Professor Dana, who submitted them to Doctor Newberry for determination. The latter gave the results of his examination in a paper published in 1891.[c] In this paper 8 new species are described and figured, but the collection contained in addition 11 species that Professor Fontaine had described from the Potomac formation in Virginia. These were identified by Professor Fontaine himself, to whom Doctor Newberry had sent the specimens. It also contained a considerable number of species occurring in the Lower Cretaceous deposits, especially from the Kome beds of Greenland. Three of the species were among those found in the Kootanie of Alberta.

[a] School of Mines Quarterly, Vol. VIII, July, 1887, p. 329.

[b] Cretaceous floras of the Northwest Territories of Canada, by Sir William Dawson: Am. Naturalist, Vol. XXII, November, 1888, pp. 953–959.

[c] Flora of the Great Falls coal field, Montana, by J. S. Newberry: Am. Journ. Sci., 3d ser., Vol. XLI, March, 1891, pp. 191–201, pl. xiv.

Other collections were made not only by Mr. Williams but also by Mr. O. C. Mortson, Dr. A. C. Peale, Dr. F. H. Knowlton, and Mr. W. H. Weed. Several of these collections found their way to Washington and were sent to Professor Fontaine for determination. His report upon them was published in 1892.[a] In this paper 15 species and varieties are enumerated, 6 of which were new. Of the others 1, *Pecopteris Browniana* Dunk. (now referred to Cladophlebis), had been previously reported from the Great Falls coal field, 5 were Potomac plants, and 3 were Lower Cretaceous or Wealden plants of Arctic or European beds. The new species, *Zamites montanensis*, is a beautiful frond with a decidedly Jurassic aspect. It is not to be confounded with the *Zamites montana* of Dawson from the Kootanie of Alberta, a much smaller plant.

In 1891 Mr. H. M. Ami and Dr. Hayden made collections of fossil plants from the Kootanie in the Cascade coal basin of the Rocky Mountains, which were worked up by Sir William Dawson and reported upon the following year.[b] The material must have been poor, as many of the forms were not specifically determined, but the new species *Angiopteridium canmorense*, which has now been found in the Shasta formation of California, was among them. Beyond this these collections added little to what had previously been obtained. At the close of the paper all the species known from the Kootanie are enumerated, and the Queen Charlotte Islands beds are correlated with these, although there are no species common to both regions. As to the probable age of the Kootanie he says (p. 93):

> With reference to the age of the above flora, it is to be observed that the species are almost entirely different from those of the Middle and Upper Creteceous, that they include some forms usually regarded as Jurassic, but that the greater number have the facies of the Lower Cretaceous. It is also observable that no angiospermous exogens are included, though had these been present at least in any considerable numbers they could scarcely have escaped detection. In the next succeeding or Mill Creek Group plants of this type occur, though not in large numbers. In the Potomac Formation of Fontaine there are, however, considerable numbers of true exogens.
>
> These facts seem to indicate that the Kootanie flora belongs to the lowest portion of the Cretaceous, and may be a little older than that of the main part of

[a] Description of some fossil plants from the Great Falls coal field of Montana, by William M. Fontaine: Proc. U. S. Nat. Mus., Vol. XV, Washington, 1892, pp. 487–495, pl. lxxxii–lxxxiv.

[b] Correlation of early Cretaceous floras in Canada and the United States, by Sir William Dawson: Trans. Roy. Soc. Canada, Vol. X, Sect. IV, 1892, pp. 79–93.

the Potomac Formation. It will be observed that while individuals of some species are abundant in the collection, they are in a condition so imperfect that some doubts must rest on their identification, and further investigation may throw much light on their age and affinities. There can, however, be scarcely any doubt as to their general reference to the Neocomian group of the Lower Cretaceous, and to the lower part of the earlier or Lower Cretaceous as held by the Canadian Geological Survey, and as recently fully illustrated for the United States in the Bulletin of the United States Geological Survey.

The following list embraces all the Kootanie plants that had been reported prior to the year 1895, when I visited the Great Falls coal basin and made my collection:

Angiopteridium canmorense Dn	Canada.
Anomozamites acutiloba Heer?	Canada.
Anomozamites sp. Dn	Canada.
Antholithes horridus Dn	Canada.
Asplenium Dicksonianum Heer	Canada.
Asplenium distans Heer	Canada.
Asplenium martinianum Dn	Canada.
Baiera brevifolia Newb	Great Falls.
Baiera longifolia (Pom.) Heer	Canada.
Baieropsis sp. Dn	Canada.
Carpolithus virginensis Font	Great Falls.
Carpolithus sp. Dn	Canada.
Cephalotaxopsis sp. Dn	Canada.
Chiropteris spatulata Newb	Great Falls.
Chiropteris Williamsii Newb	Great Falls.
Cladophlebis angustifolia Newb	Great Falls.
Cladophlebis Browniana (Dunk) Sew	Canada and Great Falls.
Cladophlebis constricta Font.?	Great Falls.
Cladophlebis distans Font.?	Great Falls.
Cladophlebis falcata Font	Canada.
Cladophlebis heterophylla Font	Great Falls.
Cladophlebis parva Font	Great Falls.
Cladophlebis sp. Dn	Canada.
Cycadeospermum rotundatum Font.?	Great Falls.
Cyperites sp. Dn	Canada.
Dicksonia sp. Dn	Canada.
Dioonites borealis Dn	Canada.
Dryopteris angustipinnata montanensis (Font.) Kn	Great Falls.
Dryopteris fredericksburgensis (Font.) Kn	Great Falls.
Dryopteris monocarpa (Font.) Kn	Great Falls.
Dryopteris montanensis (Font.) Kn	Great Falls.

Equisetum Lyellii Mant. ..... Canada and Great Falls.
Ginkgo lepida Heer ..... Canada.
Ginkgo nana Dn ..... Canada.
Ginkgo sibirica Heer ..... Canada.
Gingko sp. Dn. (nuts) ..... Canada.
Glyptostrobus grœnlandicus Heer ..... Canada.
Glyptostrobus ramosus Font ..... Great Falls.
Leptostrobus longifolius Font ..... Canada.
Oleandra arctica Heer ..... Great Falls.
Osmunda dicksonioides Font ..... Great Falls.
Pagiophyllum sp. Dn ..... Canada.
Pecopteris microdonta Font ..... Great Falls.
Pecopteris montanensis Font ..... Great Falls.
Pinus anthraciticus Dn ..... Canada.
Pinus Nordenskiöldi Heer ..... Canada.
Pinus susquaensis Dn ..... Canada.
Podozamites distantinervis Font.? ..... Great Falls.
Podozamites lanceolatus (L. & H.) Fr. Br. ..... Canada.
Podozamites latipennis Heer ..... Great Falls.
Podozamites latipennis Heer ..... Great Falls.
Podozamites nervosa Newb ..... Great Falls.
Sequoia acutifolia Newb ..... Great Falls.
Sequoia ambigua Heer? ..... Great Falls.
Sequoia fastigiata Heer? ..... Great Falls.
Sequoia gracilis Heer ..... Great Falls.
Sequoia Reichenbachi (Gein.) Heer ..... Great Falls.
Sequoia rigida Heer ..... Great Falls.
Sequoia Smittiana Heer ..... Canada and Great Falls.
Sphenolepidium pachyphyllum Font.? ..... Canada.
Sphenolepidium virginicum Font ..... Great Falls.
Spenolepidium sp. Dn ..... Canada.
Sphenopteris latiloba Font ..... Canada.
Sphenopteris sp. Dn ..... Canada.
Taonurus incertus Dn ..... Canada.
Taxodium cuneatum Newb ..... Canada.
Thyrsopteris brevifolia Font.? ..... Great Falls.
Thyrsopteris brevipennis Font ..... Great Falls.
Thyrsopteris insignis Font ..... Great Falls.
Thyrsopteris microloba alata Font ..... Great Falls.
Thyrsopteris rarinervis Font ..... Great Falls.
Williamsonia ? sp. Dn ..... Canada.
Zamites acutipennis Heer ..... Canada.
Zamites apertus Newb ..... Great Falls.

Zamites borealis Heer	Great Falls.
Zamites montana Dn	Canada and Great Falls.
Zamites montanensis Font	Great Falls.
Zamites sp. Dn	Canada.

Of these 77 forms only 4 are common to the Kootanie of Canada and the Great Falls coal field, and the number found in Canada and in Montana is nearly the same: Canada, 36; Great Falls, 37; common to both, 4. A large number are common to these beds and to the Potomac formation, while the flora that comes next in point of resemblance is that of the Kome beds of Greenland. This is not the place to discuss these relations, which can be better done after all the Lower Cretaceous floras have been treated, but the above list is of interest as showing what had been accomplished in making known the flora of the Kootanie formation down to the year 1892.

In October, 1894, Mr. Walter H. Weed discovered fossil plants in coal openings some 40 miles east-southeast of Great Falls, a little over the divide between the Missouri and Judith rivers, among small coulées that drain into the Dry Fork of Arrow Creek, about 6 miles south of Grafton. He made a small collection, or rather several small collections, from different points in the same coal field. One of his localities is said to be on Trout Creek and another on Shonkin Creek, in the Highwood Mountains, but the largest and best of the collections bears the label "foothills of the Little Belt Mountains about 5 miles south of Grafton, Mont." The next best collection was labeled "Gilt Edge Coal Mine, Montana."

Mr. Weed turned these collections over to Dr. F. H. Knowlton, and by him they were sent to Professor Fontaine for examination. His report was submitted on April 23, 1895, and was ultimately published by Mr. Weed, to whom I sent it, in the Eighteenth Annual Report of the United States Geological Survey, Part III, page 481, which did not appear until the end of 1898.

All these circumstances increased the desire I had long felt to visit the Great Falls coal field, and if possible to make a large collection that would be adequate to settle the question as to the true position of the plant-bearing beds, and particularly of those from which Mr. Weed had made these collections. Accordingly, on my way to the Pacific coast that season I stopped at Helena and proceeded to Great Falls, which place I reached on August 24. On the following day Mr. O. C. Mortson accompanied me to

several of the plant beds in and near the town, from which he and others had made collections. They seem to represent three horizons, and collections which he showed me at his house indicated as many somewhat different floras. We were unsuccessful in finding plants except at one locality, viz, that on the left bank of the river a short distance above the smelter. We did not have the proper tools for making the necessary excavations, and as I was anxious to see the beds that Mr. Weed had described, I did not make any collections there. Mr. Mortson promised to make a collection and send to me, but I have not received it.

On the 26th I proceeded by rail to Belt, and thence by private conveyance up Belt and Otter creeks to the stage station called Geyser. This place is on Hay Creek, directly north of the mines where Mr. Weed obtained his best collections, and I made it my base of operations. On the 27th I went to the mines about 6 miles south of Geyser. The first day was chiefly spent in a vain search, and several coal openings visited proved barren. I had some notes from Mr. Weed as to the localities, but they were not sufficiently definite to render it certain that I found the precise spot where he obtained the plants. In fact, I am satisfied from his description, and from the indications he gave me on a map, that I did not find his locality, as the map was inaccurate, and nothing corresponding to his indications was found. But it was not necessary to find his locality, as fossil plants occur at many of the abandoned coal openings, and a small collection was made from one of these late in the day. Here the plants occur in dark clay 2 feet above the top of the mine. The clay tended to break into cubes, so that only small pieces could be obtained. The following day a much better locality was found in another mine only a few hundred yards from the first. Here the plants occurred in the roof of the mine, which was simply an opening in the side of a ravine. Large pieces of the dry and fine-grained drab-colored clay could be detached, brought out, and worked up. Fine specimens of large impressions were obtained by splitting the slabs, which was easily done, the plants forming natural planes of cleavage. Two days were spent in this work, and a large collection was made, filling six boxes. In the bed of Hay Creek north and east of Geyser I found considerable silicified wood, which probably belongs to the same formation as the coal, but thus far none of this has been studied.

After my return from the field, viz, during the month of November, I unpacked the specimens, labeled them, and made a preliminary study of them.

As Professor Fontaine was engaged the entire winter of 1895–96 in determining the collections from the Black Hills, the Kootanie collection was not sent to him till the end of March, 1896. Mr. Weed's collections were still in his hands, and he worked them up all together. After a preliminary examination he wrote me, under date of April 20, 1896, as follows:

> I have gone carefully over all the Montana material. The flóra is distinctly Neocomian, but in the grouping of species quite unique. It has very little in common with the Potomac, and not much with the plants of the Great Falls district. Many of the species are new, and most of those that may be identified with described species belong to the Wealden of Hanover or to the Neocomian of Japan. Dunker's plant, now called *Nilsonia schaumburgensis*, is conspicuous for its abundance.

It was about this time that the present series of papers was planned, and it then became necessary to take up the older Mesozoic material in advance of the Cretaceous. The Jurassic flora of Oroville, Cal., of which the principal collections were made by me the same season as those from Montana, was put through and the work on the Kootanie plants delayed. It was not until June 14, 1897, that Professor Fontaine's final report on all the collections was completed and forwarded to me by him.

The following is Professor Fontaine's final report on the collections made by Mr. Weed and myself in the vicinity of Grafton and Geyser:

NOTES ON SOME LOWER CRETACEOUS (KOOTANIE) PLANTS FROM MONTANA.

By Wm. M. Fontaine.

In April, 1895, I received from Dr. F. H. Knowlton 10 specimens of fossil plants, with the request that I should examine them, as Doctor Knowlton recognized them as indicating a Kootanie age for the strata yielding them. They had been collected by Mr. W. H. Weed in the summer of 1894, near Grafton, Mont., on the flanks of the Little Belt Mountains. Somewhat later Doctor Knowlton sent me 5 additional specimens from the same locality, collected by Mr. Weed.[a]

[a] These are the collections mentioned above, upon which Professor Fontaine reported in April, 1895, which report was published by Mr. Weed in the paper of Weed and Pirsson, on the Geology and Mineral Resources of the Judith Mountains of Montana: Eighteenth Ann. Rep. U. S. Geol. Survey, Pt. III,

As these fossils showed some forms not previously found in the Kootanie flora, and as the new field promised to be of unusual interest, Professor Ward was induced to visit it in the summer of 1895, for the purpose of making larger collections. In this he was very successful, making a considerable collection of selected specimens. The rock material of the specimens collected by Professor Ward and Mr. Weed is identical and the plants are the same, indicating that although Professor Ward did not succeed in finding the precise spot from which Mr. Weed collected his specimens, the two collections were made from essentially the same beds. It is the object of this paper to describe the plants found in both collections.

The spot from which these specimens were collected is situated in Cascade County, Mont., 5 or 6 miles south of the stage station of Geyser and 40 miles east-southeast of Great Falls. The plants occur in a fine-grained, very fissile shale, that has a lead-gray color. The shale is connected with a coal seam, and Weed's specimens come from the roof shales of a coal seam. From the nearness of this locality to Great Falls, where plants had been previously collected, we might infer that the Geyser plants occur in the same formation. This their general character confirms. In speaking of the strata which yield the fossils I shall designate them the Geyser beds.

The shale in which the fossils are found is well fitted to preserve them in great perfection, but unfortunately they seem before entombment to have been long immersed in water. Hence they are found in small fragments, but some of these show even the most delicate parts and impressions.

Besides this a considerable number of the species are represented by numerous specimens, selected to show as much detail as possible, so that a good deal of the character of the plants may be made out by putting them together. Owing to the fine-grain and paper-like cleavage of the shale a number of details are shown with uncommon distinctness.

Considering the large amount of material the number of species is

1898. (See pp. 481–482.) Professor Fontaine was not aware that his previous report had been published, and in the final elaboration treated all the collections together, not preserving any of the memoranda made in determining Mr. Weed's collections. As a consequence it has proved impossible in most cases to identify the types of his first report. Nearly all those selected for illustration were from my own collections. Mr. Weed's specimens are generally very imperfect, and I have not attempted to have any drawn that were not selected for this purposely by Professor Fontaine.—L. F. W.

surprisingly small. From the collections made in the Great Falls coal field that I have examined I get the impression that this feature is characteristic of the flora of that field also, for apparently even large collections yield only a few species, these having many specimens. I find here again illustrated a fact observed before: I have noticed that any layer that contains a large amount of Equisetum shows very little of other identifiable plants. Equisetum, in some of the layers of shale from the Geyser locality, is exceedingly abundant, and in the same layer other species that can be made out are rare.

DESCRIPTION OF THE SPECIES.

Phylum PTERIDOPHYTA (Ferns and Fern Allies).

Order FILICALES (Ferns).

Family CYATHEACEÆ.

Genus DICKSONIA L'Héritier.

Dicksonia montanensis Fontaine n. sp.

Pl. LXXI, Figs. 1–4.

Of this plant only fructified forms were found. The frond was probably tripinnatifid at least, as the largest portions found seem to be pinnæ belonging to larger parts of the frond. The rachis of the principal pinnæ seen is comparatively stout and rigid, and in the less modified forms, such as are depicted in Pl. LXXI, Fig. 1 (of which an enlarged pinnule is shown in Fig. 2), is almost winged by the decurrent leaves of the ultimate pinnæ. The pinnæ of the ultimate order vary somewhat in the degree of their modification to assume the fertile form. Some, as the specimen figured in Pl. LXXI, Fig. 1, seem to be more foliaceous and less metamorphosed. These are the broadest forms that were found. They are decurrent on their lower side so as almost to form a wing on the principal rachis. The lower laciniæ next to the principal rachis are more united and more foliaceous than the upper ones and appear to have the sori less well developed. These pinnæ go off from the main rachis at an angle of about 45° and then turn strongly away from it, so as to stand nearly at right angles to it. They are oblong-

linear in shape and are cut down nearly to the midrib into strap-shaped laciniæ that bear sori at their ends, where they are slightly broader than in their other portions. The width of these pinnæ near their base is about 3 mm., and they narrow slightly toward their tips. None of them were seen entire, but they were apparently a little over 2 cm. in length. Both the midnerve and the lateral nerves seem to have been slender and could not be distinctly seen. The sori at the ends of the laciniæ are comparatively large and appear to be opened by the pressure of the rock matter so as to expose their upper surface. They are more or less rounded in form and slightly depressed in their central portions, so as to appear saucer shaped. No central column, as in Thyrsopteris, was seen in the sori, but the sporangia appear to have been scattered over the whole of their upper surface. The sporangia were proportionally quite large, as the pits left by them are to be distinctly seen with the help of a good lens. The pitting caused by the falling out of the sori produces a sort of granulation on the upper surface of the sori. The appearance presented now by the sori on these forms suggests the idea that they are compressed so as to open the valves of the involucre, if this existed, and expose the parts contained within them.

In some specimens, such as that shown in Pl. LXXI, Fig. 3, of which an enlarged pinnule is shown in Fig. 4, the metamorphosis of the pinnæ seems to be carried farther and little appearance of a foliaceous nature is shown. These pinnæ are cut down rather more deeply and no difference is shown between the laciniæ toward their bases and those higher up. The laciniæ are more narrowed and thickened than in Fig. 1 and look like pedicels. They are slightly broader at their summits, where they carry the sori. The narrowed laciniæ with the sori look like clubs. These pinnæ, so far as seen, are a little less than 3 mm. wide. They are about 2 cm. long and are linear in form. They are inserted on the main rachis as are those shown in Pl. LXXI, Fig. 1, and like them are slightly decurrent. The sori borne at the summits of the laciniæ are, in these pinnules, rounded or sometimes slightly reniform. They present a smooth surface and show more of the indications of sporangia than are to be seen in the forms depicted in Pl. LXXI, Fig. 1. If, as is probable, the sori are furnished with a 2-valved involucre, as in Dicksonia, the forms represented in Fig. 2 show them with the valves closed and exposing only the outer surface of one of the valves.

The plant to which these forms belong was evidently a fern of small size and apparently herbaceous in habit. It seems to have had finely cut sterile leaves, of thin but firm and durable texture. The structure of the sori could not with positiveness be made out in detail, but agrees best with Dicksonia among living ferns. The different forms agree best with the supposition that the involucre was bivalved, with the sporangia sessile and covering the inner surface of the sorus. While the bivalve nature of the involucre is not certainly shown the sori are evidently large, single, orbicular to reniform, and borne at the summit of a nerve included in a thickened and much narrowed lobe of the pinna. The form given in Pl. LXXI, Fig. 3, bears a striking likeness to Thyrsopteris, but that given in Fig. 1 shows that, unlike Thyrsopteris, the subdivisions of the pinna are not wholly metamorphosed, but still retain something of their foliaceous character. In Dicksonia the laciniæ are narrowed and thickened, it is true, but not nearly so much so as in this plant. I have with hesitation placed this Montana fossil with this latter genus. It is very near the Jurassic plant Heer has described as *Dicksonia clavipes*,[a] but is obviously a different species. It is possible that both of these plants are not true Dicksonia, but a new genus intermediate between Dicksonia and Thyrsopteris. It is highly probable that in this early period there were such connecting links between these two genera that are so near together.

Dicksonia pachyphylla Fontaine.[b]

Pl. LXXI, Figs. 5–11.

Several small and imperfect specimens of a fern were found that seem to be a Dicksonia different from *D. montanensis*. Several of them are fruiting, and one is a portion of a sterile pinnule (Pl. LXXI, Fig. 5). I am not sure that this form belongs to the same plant with that showing the specimens in fruit, and am equally in doubt whether or not the fruiting forms belong together. All of them, however, have a similar facies and have characters in common that justify placing them provisionally in the same species until more and better specimens are obtained. All of them have a rather broad, flat midrib, with strong lateral nerves

[a] Fl. Foss. Arct., Vol. IV, Pt. II: Beiträge zur Jura-Fl. Ostsibiriens und d. Amurlandes, p. 33, pl. ii, fig. 7.

[b] See p. 224.

and a thick, apparently coriaceous leaf substance that leaves a film of carbon on the rock. The fertile specimens are such as we should expect to be found if the sterile pinnule depicted in Pl. LXXI, Fig. 5, underwent such modifications as are found in the fertile pinnules of a Dicksonia. The two fertile portions of pinnules given in Pl. LXXI, Figs. 7 and 9, differ decidedly from the fertile pinnules of *D. montanensis*, and this fact has induced me to make, but with doubt, a new species of these forms. The material is much too imperfect and scanty to permit their proper place to be determined with any degree of positiveness.[a]

The form given in Pl. LXXI, Fig. 7, differs somewhat from that shown in Fig. 9, but the difference is of the same nature as that shown in the two fertile forms of *Dicksonia montanensis;* that is, the form shown in Fig. 7 is more modified and less foliaceous than that given in Fig. 9.

The sterile form depicted in Pl. LXXI, Fig. 5, is the fragmental terminal portion of what must have been a rather large pinnule. It reminds one somewhat, in size and nervation, of the sterile pinnules of the living *Dicksonia sorbifolia* Smith; only the terminal portion of the pinnule is preserved to such an extent as to give some idea of its shape. The lamina on the left side of the lower part of it is wholly wanting, and on the corresponding right-hand portion the margin is gone, so that we can not determine whether or not the lower portion of the pinnule had dentate margins like the upper portion. It probably had.

The lateral nerves are strong and in all parts of the pinnule fork near their departure from the midrib. In the lower part of the pinnule not enough is shown to disclose certainly the entire course of these nerves, but one, on both of the branches, apparently forks again. In the terminal toothed portion there is no second forking and each branch terminates in a tooth, as is shown in the magnified portion, Pl. LXXI, Fig. 6.

The fragment represented in Pl. LXXI, Figs. 7 and 8, is a small bit of a fertile pinnule with relatively large sori, placed close to the

[a] Better material was obtained from the Shasta formation described later by Professor Fontaine, but inserted earlier in this paper.—L. F. W.

midrib and supported on short laminæ that are so much modified that they are reduced to thickened veins. This form, in the large sori and short stout pedicels carrying them, is even more like Heer's *Dicksonia clavipes* than the fertile forms of *D. montanensis*. Pl. LXXI, Fig. 8, gives a portion of this magnified to show the sori, which, belonging to a Dicksonia, have their valves closed and showing their outer surface. Pl. LXXI, Fig. 9, represents a somewhat different fragment of a fertile pinnule, which has also large sori on short supports. But these latter are more foliaceous than those shown in Fig. 7, and have on each side of the nerve which bears the sori at its summit a wing formed by a remnant of the lamina of the pinnule, giving a form apparently not so much altered from the sterile pinnule as is that figured in Fig. 7. This wing, however, is thickened and gives with the sorus a club-shaped or spatulate form. Fig. 10 gives a portion of this magnified. Fig. 11 represents the small specimen collected by Mr. Weed at the Gilt Edge coal mine in the Judith Mountains, about 50 miles east of the place where most of the other specimens were obtained. Its chief importance is due to the fact that it was upon this specimen that the author founded the species.

The plant occurs in both Professor Ward's and Mr. Weed's collections.

Genus THYRSOPTERIS Kuntze.

THYRSOPTERIS ELLIPTICA Fontaine.

Pl. LXXI, Figs. 12, 13.

1889. *Thyrsopteris elliptica* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 133, pl. xxiv, figs. 3, 3a; pl. xlvi, figs. 1, 1a; pl. l, figs. 6, 6a, 9; pl. li, figs. 4, 6a, 6b; pl. liv, fig. 6; pl. lv, fig. 4; pl. lvi, figs. 6, 6a, 7; pl. lvii, figs. 6, 6a; pl. lviii, figs. 2, 2a.

1898. *Thyrsopteris elliptica* Font.? in Weed & Pirsson: Eighteenth Ann. Rep. U. S. Geol. Surv., 1896–97, Pt. III, p. 482. (Pl. LXXI, Fig. 13.)

Two specimens of a fern apparently identical with *Thyrsopteris elliptica*, a characterisic plant of the Lower Potomac of Virginia, were found, one by Mr. Weed at the Grafton locality and the other by Professor Ward near Geyser. The latter is figured in Pl. LXXI, Fig. 12, and the former in Fig. 13. They are fragments of ultimate pinnæ, but contain pinnules sufficiently well preserved to leave little doubt that they belong to the Potomac plant.

Family POLYPODIACEÆ.

Genus CLADOPHLEBIS Brongniart.

Cladophlebis falcata montanensis Fontaine n. comb.

Pl. LXXI, Figs. 14–20.

1898. *Thinnfeldia montanensis* Font. in Weed & Pirsson: Eighteenth Ann. Rep. U. S. Geol. Surv., 1896–97, Pt. III, p. 481.

Plant probably arborescent; so far as seen, tripinnatifid. Only fragments of pinnæ have been found. These contain a varied number of portions of pinnæ, showing pinnules on different parts of the pinnæ, and as the specimens are numerous a pretty good idea of different parts of the plant can be formed. The rachises of the pinnæ are strong and rigid. The pinnules vary in character with their position on the pinnæ and fronds. Low down on the pinnæ and frond they are long, linear, and narrow, narrowing very gradually from their bases to their tips. Fragments have been 45 mm. long and 5 mm. wide, indicating an entire pinnule considerably longer. These have not been found attached, although several occur together on some of the specimens, as if coming from the same rachis. These pinnules have their margins more or less incised, as represented in Pl. LXXI, Fig. 15, the incisions varying in depth from crenulations to rounded lobes cut halfway down to the midnerve. These forms indicate that lower down on the frond the lobes will pass into pinnules of the normal kind. Higher up on the pinnæ and frond the crenulate pinnules become entire, giving what we may call normal pinnules. Toward the ends of the pinnæ and throughout those of higher parts of the frond the pinnules become smaller and more and more united. The normal pinnules from the middle of the pinnæ are about 3 cm. long, as shown in Pl. LXXI, Fig. 17. They are widest at base and separate, but are very closely placed. They are strongly falcate, alternately placed, and narrow gradually to a subacute tip. The pinnules had apparently a coriaceous texture, so that the fossils have a rigid aspect. They are united to the rachis by their entire base, which is expanded and has the midnerve eccentrically placed, so that the width of the lamina of the pinnule in front of or above it is greater than that of the portion below.

The nervation varies with the pinnules. It is very distinct and sharply defined. In this respect it surpasses that of the forms of this species found in the Potomac formation of Virginia. As stated, the long crenate pinnules were not seen attached, but in the normal pinnules with entire margins the midnerve leaves the rachis at an acute angle and enters the pinnule near its lower basal margin, so as to divide the lamina into unequal parts. It becomes very gradually attenuated, and, as is the case with Cladophlebis, splits up at its end into several branches. The lateral nerves of the normal pinnules, although distinct, are rather slender. They go off very obliquely from the midrib and curve outward toward the margin of the pinnules. They fork near their insertion, and each branch forks again at about the middle of the lamina, while the branches continue nearly parallel to one another until they meet the margin. This nervation reminds one of that of the small-pinnuled neuropterids of the Paleozoic. The basal nerve bundle on each side of the midnerve is inserted, not on the midnerve, but at the point of its attachment to the rachis of the pinna.

The lateral nerves of the long crenate and of the lobed pinnules form nerve bundles that go off obliquely from a common point of insertion and are composed of several branches, which in turn split up into others, the whole group diverging flabellately and curving away from the midrib to meet the margin at a large angle. These nerves are rather coarse. The nerve bundles fill the lobes and crenate incisions. All the lateral nerves, in every part of the plant, are noteworthy for the length of the branches into which they split up. In the pinnules toward the ends of the pinnæ and in the upper part of the frond the lateral nerves are forked only once.

This fine fern is one of the most abundant fossils in the Geyser group of strata and it is the best preserved. A large number of impressions of good size and belonging to different portions of the plant have been found. In these we find some features different from the character of *C. falcata*, as made out from the fossils of the Potomac beds of Virginia.[a]

It may be questioned whether or not these forms show enough difference from the species of the Virginia Potomac to justify their

[a] Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), pp. 72, 73, pl. iv, fig. 8; pl. v, figs. 1–6; pl. vi, fig. 7; pl. vii, figs. 1, 2.

separation as even a variety. These pinnules are commonly longer and narrower, especially toward their tips, which narrow more gradually than those of the Virginia plant. They are also more acute. No forms were found in the Virginia specimens that showed any indication of undulation or lobing. Although these differences are slight, and hence of no great weight, it seems to be the better usage, in the case of plants that grew in widely separated localities, to allow them more weight in separating than in uniting forms. The presumption is that the plants are different, and the burden of proof is with the person who would unite them. Nonessential features that are not admitted as justifying the formation of new species certainly can not be taken as establishing the identity of plants that grew in situations separated by thousands of miles. Still less can such features be admitted as indicating identity, when the plants grew in different times. Then, too, if the new species or variety turns out to be identical with some known form it is easier to drop its name than to restore it to independence when it is shown to have been improperly merged with some previously described plant.

Pl. LXXI, Fig. 14, represents a portion of a pinna carrying parts of a number of pinnules with undulate margins. It will give a good idea of the size that the rachis of the pinnæ attained, but unfortunately the pinnules are not well enough preserved to give their full dimensions and shape. Fig. 15 gives a portion of a crenately incised pinnule, which, when entire, was evidently considerably longer than the specimen. Some of the crenate pinnules found are wider than this by a half. Fig. 16 represents one of the lobes enlarged to show the nervation. Fig. 17 gives a fragment of one of the pinnæ containing a number of normal entire pinnules from the middle portion of a pinna and frond. Fig. 18 represents a pinnule of this magnified to show the nervation. A number of the pinnules of this specimen show on their surface markings that look strikingly like elliptical sori. They are, however, not placed according to any definite plan, but occur on any part of the pinnule, sometimes on different nerves and on different parts of them and sometimes between the nerves. They are probably due to some fungoid disease. Fig. 19 shows the terminal portion of a pinna, with the diminution in that part of the size of the pinnules and their increasing consolidation toward the ends of the pinnæ.

In Mr. Weed's collection there was an imperfectly preserved fragment of a fern which, from its Neuropteris-like nervation, was supposed to be probably a new Thinnfeldia. In the previously mentioned preliminary report the provisional name *T. montanensis* was proposed for it. In Professor Ward's collection the number of larger and much better preserved specimens of this plant obtained show that this is a variety of *Cladophlebis falcata*. This specimen is represented on Pl. LXXI, Fig. 20.

CLADOPHLEBIS HETEROPHYLLA Fontaine.

Pl. LXXI, Figs. 21–25.

1892. *Cladophlebis heterophylla* Font.: Proc. U. S. Nat. Mus., Vol. XV, p. 493, pl. lxxxiv, fig. 2.

A considerable number of specimens of a small fern were found in the Geyser beds which appears to be identical with *Cladophlebis heterophylla* Font. This was found in two small and rather imperfect specimens in the strata of the Great Falls coal field of Montana, and was described by me in a paper entitled "Description of some Fossil Plants from the Great Falls Coal Field of Montana," published by the National Museum, Vol. XV, pp. 487–495, with plates lxxxii–lxxxiv. The description is given on page 493, and the plant, so far as then known, is figured on pl. lxxxiv, fig. 2. In the description it was stated that the full character could not be made out owing to the imperfect and scanty material. In the Geyser beds a considerable number of specimens were found. Some of these are much larger than those from Great Falls and better preserved, so that they show more of the nature of the plant. At the same time, by taking specimens from different parts of the plant its character can be better made out. The nervation was shown only vaguely in the fossils from Great Falls, while it is clearly exhibited in some of the Geyser specimens. None of the forms from the Geyser locality show the diminution of the ultimate pinnæ toward the base of the primary pinnæ which is seen in the Great Falls fossil, and which was taken as one of the features forming its specific character. This must accordingly be regarded as a distortion due to some local cause.

Again, in the more numerous forms from Geyser we are enabled to see that the fern showed some variability in the normal or common pinnules. The inferior pinnule, however, at the base of each ultimate pinna, next to

the rachis of the penultimate pinna, is constantly, in these specimens also, abnormal in size and shape, being of the same character as in the Great Falls forms. This is a constant and characteristic feature. The normal or common pinnules also are essentially the same in character as those from Great Falls, but are generally somewhat larger. The size of the normal pinnules on some of the Geyser plants indicates a fern considerably larger than the form most commonly occurring, and their shape is somewhat different. But these larger pinnules are connected in shape and size by transition forms with the more common ones in such way as to forbid a separation even as a variety.

This fern, in the shape of its pinnules and in its nervation, strongly reminds one of the Acrostichites forms seen in the flora of the Older Mesozoic of Virginia. As, however, no fructification has been found on any of the specimens, it must be placed in the group of Cladophlebis, which is based on nervation. It is true that this type of nervation departs somewhat from the common types of Cladophlebis, but not enough to prevent the placing of the plant in that comprehensive genus. In consequence of the more complete and numerous specimens now found, the character of the species must be corrected to read as follows:

Fronds at least tripinnate; primary rachis slender; secondary pinnæ alternate, very remotely placed, slender and proportionally quite long and narrow; pinnules, other than the inferior basal ones, of two kinds, those that occur most commonly, which we may call the normal ones, and those less common, which, for distinction, may be called abnormal. The normal pinnules are very small, mostly 2 mm. long and about as wide at their bases. They are generally remotely placed and are united at base, so as to form a very narrow wing on the rachis. In shape they are subrhombic to suborbicular and very obtuse at their tips, or even rotundate there. The longer ones are subfalcate, and all are united to the rachis by the whole of a much widened base. The basal inferior pinnules of the ultimate pinnæ carrying these normal pinnules are much larger than the latter, and are mostly flabellately 3-lobed, the lobes being shallow, more or less rounded and obtuse. The nervation of the normal pinnules is strong but not very sharply defined. It consists of a nerve bundle, which departs from the rachis of the ultimate pinna much nearer the inferior then the superior margin of the pinnule, so as to divide it into two very unequal parts.

Immediately after leaving the rachis the bundle splits up into about three principal branches, and these branch again several times, the entire group diverging flabellately so as to fill the pinnule. The nervation then is much like that of the Acrostichites of the Older Mesozoic flora of Virginia. It may be compared with that of *A. microphyllus* Font., a plant which is a good deal like the one now in question and which was described in Monograph United States Geological Survey, Vol. VI, page 33.

The nervation of the inferior basal and flabellate pinnules is conformed to the shape of these pinnules. It consists of a nerve bundle which splits into three main branches, one of which goes into each lobe of the pinnule, giving off diverging and forking branches which fill each lobe. In the less commonly occurring abnormal forms there is some variation from the type shown in both the basal inferior pinnules and in those on the other portions of the ultimate pinnæ. The basal inferior pinnules are less deeply lobed than those on the pinnæ with normal pinnules, more elliptical in shape, and strongly deflexed along the rachis of the penultimate pinnæ. They are either elliptical or spatulate in form.

The other pinnules of these forms are mostly larger than the normal ones. They are ovate to elliptical in shape, obtuse to subacute, rounded off at base on both the lower and the upper side, owing to an abrupt narrowing of the pinnule immediately at its attachment to the rachis of the pinna. Some of the forms that are subacute are sometimes even acuminate from the gradual narrowing of the pinnules toward their tips. The nerves in all the pinnules of the abnormal forms are of the same type as those of the corresponding ones on the normal forms, but the nerves of the more common pinnules are apparently thicker and more vaguely defined than those of the corresponding normal ones.

Pl. LXXI, Fig. 21, represents a penultimate pinna, carrying portions of several ultimate pinnæ, which well show the small pinnules that constitute the normal forms, and also their accompanying basal pinnules. Fig. 22 gives two of the normal pinnules magnified four diameters, to show the nervation. Fig. 23 represents a portion of a pinna of the abnormal kind, containing the largest pinnules found, and Fig. 24 gives a part of a primary pinna of the abnormal kind, which carries portions of three ultimate pinnæ, showing well the form of the more acute pinnules of this kind, and also portions of their accompanying basal deflexed pinnules. The nerves

of the ordinary small pinnules of this specimen appear to be quite coarse and interrupted in length, which makes the parts visible look like the linear sori of an Asplenium; otherwise their plan, and that of the nerves of the basal pinnules, are the same as that of the normal pinnules.

In Mr. Weed's collection from the Grafton beds a specimen of a small fern resembling Acrostichites was seen and regarded as a new species. No name was proposed for it in the preliminary report, but it was compared with Dunker's Wealden species *Pecopteris Geinitzii*. The many specimens of it occurring in Professor Ward's collection show that this is *Cladophlebis heterophylla*. This specimen is represented in Pl. LXXI, Fig. 25.

CLADOPHLEBIS CONSTRICTA Fontaine.

Pl. LXXI, Fig. 26.

1889. *Cladophlebis constricta* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 68, pl. ii, figs. 11, 11a, 11b; pl. iii, fig. 2; vi, figs. 5, 5a, 6, 6a, 8, 8a, 9, 9a, 10, 11, 11a, 11b, 12–14; pl. xxi, figs. 9, 13; pl. clxix, figs. 2, 2a.

One imprint of a fern with its reverse was found in the Geyser beds that is strikingly like *Cladophlebis constricta* Font., of the Lower Potomac strata of Virginia. The identification of this fern with the Potomac form is made questionable solely because the amount of material is not sufficient to permit positive conclusions, and not because this specimen is unlike in any respect that of Cladophlebis. In fact, the imprint is exactly like the form depicted in Monograph, United States Geological Survey, Vol. XV, pl. ii, fig. 11 (not 12, as wrongly given in that work). The description of this species given on page 68 of the same work applies equally well to the specimen now in question. The Geyser specimen corresponds to the upper pinnæ of the Potomac form given in the figure quoted. The pinnules, however, are rather smaller.

The Geyser specimen is the imprint of an ultimate pinna, probably from high up on the frond, which carries several pinnules. These are remotely placed, mostly with undulate margins, but with some having a rounded shallow lobe on each side at the base. The pinnules are rounded off and constricted at base, and in shape are ovate, sometimes elliptical and even hastate. They are thick and leathery, with obtuse to subacute tips. The nervation is of Cladophlebis type. The lateral nerves are quite coarse, but rather vaguely defined. The upper ones are once or twice forked, the

lowest ones in the basal rounded lobes are several times forked and tend to form flabellate bundles, which fill the lobes.

There is hardly a doubt that this is a species of Cladophlebis distinct from the other species of this genus found in the Geyser beds, and so far as we can judge from so small an amount of material, it is most probably identical with *C. constricta* of the Virginia Lower Potomac.

Pl. LXXI, Fig. 26, gives a representation of this form.

Order EQUISETALES.

Family EQUISETACEÆ.

Genus EQUISETUM Linnæus.

Equisetum Phillipsii (Dunker) Brongniart.

Pl. LXXII, Figs. 1–11.

1843. *Equisetites Phillipsii* Dunk.: Programm. d. höheren Gewerbschule in Cassel, 1843–44, p. 5.
1846. *Equisetites Phillipsii* Dunk.: Monogr. d. Norddeutsch. Wealdenbildung, p. 2, pl. i, fig. 2.
1849. *Equisetum Phillipsii* (Dunk.) Brongn.: Tableau, p. 107.
1869. *Equisetum Phillipsii* (Dunk.) Brongn. Schimper: Pal. Vég., Vol. I, p. 265.
1898. *Equisetum montanense* Font. in Weed & Pirsson: Eighteenth Ann. Rep. U. S. Geol. Surv., 1896–97, Pt. III, p. 481. (Pl. LXXII, Fig. 11.)

The stems of this Equisetum, when of full size, range in diameter from about 15 mm. to 2 cm. Only stems without branches were seen. The dimensions of the sheaths and teeth vary with the size of the stems. Regarding the sheath, as indicated by the striæ, it is, in the larger specimens, from 15 mm. to 2 cm. long. The internodes in the same average about 3 cm. in length. The teeth in the larger specimens average about 6 mm. in length and are 1 mm. wide at base, their widest portion. In form the teeth are narrow lancet-shaped, gradually narrowing from their bases to their tips, where they are acute. Near their margins the teeth are thickened, so that they appear almost as if furnished with lateral keels. The portions of the teeth between these margins are depressed. At their bases on the nodes the teeth are closely coherent with the stem, and each one is separated from its neighbors by a sharply defined furrow, which is widest at the bases of the teeth and narrows down the stem to a mere

line, which is, however, sharply defined. In this way a portion of the stem beneath each node is strongly striate, the striated portions being formed by the united teeth, which produce a sheath. This latter is pressed close to the stem and apparently coalesces with it. The cross section of the furrows on the sheath is V-shaped, and when casts of them are taken in the fine shale, as is commonly the case, they appear as sharp-topped ridges, widening toward the nodes. In this form they simulate teeth. The teeth are rarely found preserved, but commonly break off at the nodes, where they coalesce with the stem and leave more or less distinct truncate processes, which correspond with the bases of the teeth. The most common form preserved by the remains of this Equisetum is a strap-shaped portion of the stem, composed mainly of epidermal tissues, which shows a varying number of nodes with strongly striate portions beneath each node. Each node carries mostly rather vague, square-topped processes. In very rare cases a few teeth are preserved. Judging from the striæ and processes, the number of teeth seems to have been about 30, for as many as 13 processes have been counted on the upper face of some of the stem imprints. In a few cases the stem, at a node, has been compressed in the direction of its axis, so that the mud has been squeezed up through the node, carrying the diaphragm away, and in one or two cases it may be seen in place. In this way we may account for the frequent occurrence of isolated diaphragms.

Diaphragms of varying size, occurring detached from the stems, are not uncommon on some pieces of the shale. They vary from 5 mm. or less to about 1 cm. in diameter. They occur anywhere, sometimes on some portion of the macerated remains of the stem and sometimes on the shale, without any trace of the stem. They are wheel-shaped, with a round hole in the center, around which radiate club-shaped convexities that have their thicker portions at the periphery of the circle. When the nodes are compressed in an axial direction and some of the teeth are preserved they sometimes appear unusually long, since the sheath splits some distance down along the sinuses and thus separates the basal portions of the teeth that were formerly consolidated to form the sheath. At least that is the way I account for the unusual length of the teeth in the sheath compressed in an axial direction, which is shown in Pl. LXXII, Fig. 7.

The teeth average in length about 6 mm. They show the narrow lancet to linear form which belongs mostly to the Equiseta of late Jurassic and early Cretaceous times. The size of the stem surpasses that of the characteristic Equiseta of the Lower Cretaceous, and in this feature the plant has rather Jurassic than Cretaceous affinities. A Jurassic and Older Mesozoic character is seen also in the sheaths, which are closely consolidated with the stem, unlike the loose, baggy sheaths seen in the small Lower Cretaceous Equiseta, such as *Equisetum Burchardti* Dunk., etc. Dunker, in his Monogr. d. Norddeutsch. Wealdenbildung, established the species from a single imperfect specimen, calling it *Equisetites Phillipsii*. No other specimen of the plant seems to have been found, for all writers who notice the species base their remarks on Dunker's specimen. Schenk carefully examined Dunker's specimen and gives the fullest description of it.[a] He says that the internodes are 2 cm. in diameter and 15 mm. long; the sheaths are short, 2–2.5 mm. long, and toothed, and the bases of the teeth are persistent and truncate in form, while the stems are obscurely striate. He remarks that it is larger than any of the Wealden species.

There is nothing in Schenk's figures to show the true length of the sheaths. What he appears to regard as the entire sheath is its upper portion, where the bases of the teeth are united to the stem.

Pl. LXXII, Fig. 1, gives, natural size, a portion of a node of one of the larger-sized stems, which has been compressed in the direction of the axis of the stem so as to squeeze out the diaphragm. The upper part of a portion of the sheath is preserved and the lower portions of some of the teeth are shown. Fig. 2 shows a node compressed in a manner similar to Fig. 1. This is a smaller stem. It shows the diaphragm in place, the sheath split down along the bases of the teeth so that these appear too long. Fig. 3 shows a much compressed portion of one of the larger sized stems, which at its upper end carries the greater part of a sheath with its striæ. This is the most common form in which the remains of this plant are found. Fig. 4 represents one of the smallest sized detached diaphragms, and Fig. 5 one of the largest size. Fig. 6 shows a portion of a flattened stem with some of the processes that are left at the node when the teeth are torn off. Fig. 7 shows a portion of a

[a] Die Foss. Flor. der Nordwestdeutsch. Wealdenformation, p. 4, pl. i, figs. 6–9 (Palaeontographica, Vol. XIX, p. 206, pl. xxii, figs. 6–9).

node belonging to one of the largest sized stems. The stem has been compressed axially in such a manner as to carry away the diaphragm and split down the sheath, so as to separate the lower portions of the teeth that had been united to form the sheath. The teeth thus appear abnormally long. Their lancet shape is well shown in the upper portion of some which are preserved entire. Fig. 8 shows a node bearing several more or less perfect teeth. One of them is perfectly preserved, showing the full size and shape. Fig. 9 shows two of these teeth enlarged two diameters. This shows well also the depressions between the teeth in the sheath. Fig. 10 gives a restoration of several of the teeth and a portion of the sheath, much enlarged, to show details visible distinctly only with the help of a lens.

In my preliminary report on Mr. Weed's collection, mentioned above, an Equisetum is noticed, and as it was thought to be probably new, the provisional name *E. montanense* was suggested for it. The numerous well-preserved impressions of this plant in the collection made by Professor Ward show that this is *E. Phillipsii*. This specimen is represented in Pl. LXXII, Fig. 11.

Equisetum Lyellii Mantell.

Pl. LXXII, Figs. 12–14.

1833. *Equisetum Lyellii* Mant.: Geology of the Southeast of England, pp. 217, 227, 245, fig. 52 (1, 2, 3) on p. 245 (numbered on p. 399).
1843. *Equisetites Lyellii* (Mant.) Morr.: Catalogue of British Fossils, p. 8.
1898. *Equisetum Lyellii* Mant. Font. in Weed & Pirsson: Eighteenth Ann. Rep. U. S. Geol. Surv., 1896–97, Pt. III, p. 481.

Along with the numerous imprints of *Equisetum Phillipsii* there occur, much more rarely, imprints and fragments of the stems of a smaller Equisetum. Its character is so constantly different from that of *E. Phillipsii* that it can be distinguished at a glance. It agrees so well with *E. Lyellii*, as described by Schenk,[a] that it must be considered as identical with that Wealden species. The larger stems are about 8 mm. in width. They are not well enough preserved to show with certainty all the character of the plant. The nodes seen are 2 cm. long. The sheaths are apparently about 1 cm. in length, closely appressed to

[a] Die Foss. Flor. der Nordwestdeutsch. Wealdenformation, p. 5, pl. i, figs. 10–13 (Palaeontographica, Vol. XIX, p. 207, pl. xxii, figs. 10–13).

and consolidated with the stem. The teeth are from 5 to 10 mm. long, narrow, linear, acute at the tips, with the margins thickened so as to appear corded. The stems, in the internodes between the sheaths, are striated with narrow parallel depressed lines, differing markedly in this respect from the stems of *E. Phillipsii*, which are smooth. These furrows, when reversed by a cast being taken in the fine mud, appear as raised lines. The striation is due to the depressed lines between the consolidated bases of the teeth, which, unlike those of *E. Phillipsii*, do not narrow out, but persist from one sheath to another. The mode of striation is shown in Fig. 12, which represents two enlarged teeth with a portion of the stem at their bases.

Pl. LXXII, Fig. 12, represents a portion of a medium stem, on which two sheaths are vaguely shown, one at the top. The teeth and sheaths in all the specimens of this Equisetum are so closely appressed to the stem that they are seen with difficulty. Nearly all the specimens show casts of the true surface of the stems. Fig. 13 shows a small-sized stem with several teeth well preserved in reverse. Fig. 14 is an enlargement of a portion of a stem with two teeth and shows the thickened or corded margins of the teeth, a feature that Schenk gives in pl. i, fig. 13, of Die Fossile Flora der Nordwestdeutschen Wealdenformation representing this Equisetum. But in Schenk's figure the cording is more decided and the teeth are more strictly linear than they are in our specimens. It is possible that these smaller stems may not belong to an Equisetum different from *E. Phillipsii* but may be branches of that plant.[a]

Order LYCOPODIALES.

Family LYCOPODIACEÆ.

Genus LYCOPODITES Brongniart.

LYCOPODITES ? MONTANENSIS Fontaine n. sp.

Pl. LXXII, Figs. 15, 16

Several specimens of a small conifer occur in the Geyser strata whose proper place can not be certainly determined. The amount of material is too small and the specimens are not well enough preserved

[a] This species was mentioned by Professor Fontaine as occurring in Mr. Weed's collections, and this statement is made in Weed and Pirsson's paper, p. 481, but a careful examination of the specimens fails to show any impressions of it sufficiently distinct for illustration.—L. F. W.

to enable one to make out without doubt the genus. The largest imprint, the one given in Pl. LXXII, Fig. 15, is a fragment of an ultimate branch with a number of leaves, only a few of which are well enough preserved to show their shape and dimensions. The twigs seem to have been slender and to have had closely placed leaves, which, in their present state of preservation, are in two rows. They are only 2 mm. long and about half a millimeter wide at their bases, their widest portion. They are so closely placed that their bases overlap. In shape they are elongate-oblong, widening to the base and at the opposite end narrowing gradually to an acute tip. Their exact mode of attachment could not be made out. They appear to be decurrent, with the bases of adjacent leaves overlapping. No nerves are visible. Fig. 16 gives a fragment enlarged, showing as much detail as could be made out. The plant resembles *Araucaria obtusifolia* Font.,[a] but the leaves are much smaller, proportionally wider at base, and much more acute. It seems to be nearer Lycopodites than any other plant, and I have with doubt placed it in this genus.

Phylum SPERMATOPHYTA.

Class GYMNOSPERMÆ.

Order CYCADALES.

Family CYCADACEÆ.

Genus NILSONIA Brongniart.

Nilsonia Schaumburgensis (Dunker) Nathorst.

Pl. LXXII, Figs. 17–21.

1843. *Pterophyllum schaumburgense* Dunk.: Programm. d. höheren Gewerbschule in Cassel, 1843–44, p. 6.

1846. *Pterophyllum schaumburgense* Dunk.: Monogr. d. Norddeutsch. Wealdenbildung, p. 15, pl. i, fig. 7; pl. ii, fig. 1; pl. vi, figs. 5–10.

1870. *Anomozamites schaumburgensis* (Dunk.) Schimp.: Pal. Vég., Vol. II, p. 141, Atlas, pl. lxx, figs. 5, 6.

1889. *Nilssonia schaumburgensis* (Dunk.) Nath.?: Anzeiger d. k. Akad. d. Wiss. in Wien, Jahrg. XXVI, No. 24, p. 237.

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[a] Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 249, pl. lxxxv, fig. 13.

1890. *Nilssonia cfr. schaumburgensis* (Dunk.) Nath.: Denkschr. Wien Akad., Vol. LVII, p. 45 [5], pl. i, figs. 6–9, 9a.

1898. *Angiopteridium strictinerve* Font. in Weed & Pirsson: Eighteenth Ann. Rep. U. S. Geol. Surv., 1896–97, Pt. III, p. 481. (Pl. LXXII, Fig. 20.)

This plant was described by Dunker from the Wealden of northern Germany as *Pterophyllum schaumburgense*, and he illustrated it by a number of figures showing its variability. Schimper regarded it as an Anomozamites. In this determination he was followed by Schenk.[a] Schenk's figures show some variations not seen in those of Dunker and depict some leaves larger than any given by him. Schenk gives as the maximum length of the segments of the leaf 8 mm.

Nathorst[b] gives figures of certain long, narrow cycad leaves from Japan which he correctly regarded as belonging to Dunker's species, but as the segments are inserted on the upper surface of the midrib he held it to be a Nilsonia. Yokoyama[c] gives a number of figures of this plant and confirms Nathorst's conclusion as to its character.

Schenk states that *Nilsonia schaumburgensis* is the predominant plant in the Wealden of northern Germany. It is found in such numbers in the Geyser beds that it may be regarded, if not as the predominant plant there, at least as one of the most important. The specimens yielded by the Geyser beds fully equal in variability those found in Germany and Japan, and the same kinds of variation occur. Any of the forms hitherto figured may be matched in the Geyser fossils. The variations, however, are in nonessential points, such as the length of the leaves, the length and width of the segments, and the shape of the ends of the latter. Notwithstanding this variability the plant is so well characterized that even small fragments of it may be easily recognized. The segments go off normally at nearly or quite right angles with the midrib, but they may curve striately near their ends in a falcate manner toward the end of the leaf. Owing to distortion from pressure, this falcate shape is often exaggerated, and the same distortion tends to sharpen the ends of the segments and to round off in an elliptical form the margin of their ends. They are of nearly or quite the same width from base to

[a] Foss. Flor. der Nordwestdeutsch. Wealdenformation, p. 29, pl. xii (Palaeontographica, Vol. XIX, p. 231, pl. xxxiii).

[b] Beiträge zur Mesozoischen Flor. Japans (Denkschr. Wien Akad., Vol. LVII, p. 45), p. 5, pl. i, figs. 6–9a.

[c] Mesozoic Plants from Kozuke, etc. (Jour. Coll. Sci. Imp. Univ. Japan, Vol. VII, Pt. III, 1894), p. 227, pl. xx, figs. 12, 14; pl. xxi, fig. 14; pl. xxii, figs. 5–7.

tip when undistorted, but often from pressure become narrower at their ends. Distortion from pressure often causes the segments to incline toward the ends of the leaf, and thus they seem to go off at an angle smaller than the normal one with the midrib. They are attached by the entire width of their bases to the upper face of the midrib of the leaf, so that the adjacent bases of the opposite segments are separated by a raised line. There is some indication that with age they become more loosely attached to the midrib. At any rate the Geyser specimens show numerous detached segments that have separated from the midrib along this line. Detached segments are much more common than those borne on the midrib. This deciduous character is marked in the Geyser fossils, but is not noted by previous describers of this fossil. The frequent detachment of the segments does not seem due solely to the accidents of preservation. The width of the segments varies greatly, for some leaves have only two segments on a side and others have the lamina on each side of the midrib divided into numerous segments that are very uniform in size and shape. Others have numerous segments, but they vary greatly in width. In some cases the apparent segmentation, as well as the shape, is due to pressure, the lamina splitting on the yielding of the rock material. The width of the segments can not then be regarded as a feature of any importance, and the same may be said of the number of nerves, for that varies with the width of the segments.

The nerves, although slender, are remarkably distinct. They are always single, and when the segment is not distorted by pressure they are strictly parallel. The pressure, however, has frequently narrowed and sharpened the ends of the segments, and then the nerves are crowded in the distorted portion. The nerves are described by previous observers as going off at right angles with the midrib, whereas in the Geyser fossils they rarely do so, but more commonly make an angle somewhat smaller. In some of the figures given by Schenk they are represented as making a much smaller angle. The nerves in their course to the ends of the segments make a slightly sigmoid flexure, so that their tips are directed slightly forward. In the leaves distorted by pressure in the way mentioned before, this forward inclination is exaggerated. The nerves are thickened at the insertion of the segments on the midrib and the pressure sometimes causes them to appear as raised lines on the surface of the

midrib. This appearance is well shown in Nathorst's fig. 9a, pl. i. The help of a lens is necessary to show this feature. The same figure of Nathorst shows well the raised line in the middle of the upper face of the midrib, on each side of which the bases of the segments are attached.

The Geyser specimens show some leaves larger than any previously described. The largest segments given for plants from other localities have a length of 8 mm., but some found in the Geyser beds detached from the midrib show a length of 26 mm. Such a segment is shown in Pl. LXXII, Fig. 17. These largest segments are always found detached. Fig. 18 gives a fragment of a leaf of medium size with the segments very uniform in size and shape. Fig. 19 represents a fragment of the largest size found with detached segments. Fig. 20 gives a fragment of one of the smallest leaves. On it the segments are unequal in width and the nerves are very distinct. Fig. 21 shows a fragment of a small leaf with the lamina almost entire. Only one division of it is shown on the right side of the midrib and two on the left side. It is not certain that even this segmentation is not due to the accidental splitting of the lamina from pressure.

This plant is found in both Professor Ward's and Mr. Weed's collections. In the latter there were a few small fragments that were noted in the preliminary report as agreeing well with *Angiopteridium strictinerve* of the Potomac. A comparison of them with the very numerous and well-preserved specimens of *Nilsonia schaumburgensis* found in Professor Ward's collection showed that they are the widely detached segments of that plant. Pl. LXXII, Fig. 20, represents the best specimen collected by Mr. Weed.

Genus ZAMITES Brongniart.

ZAMITES ARCTICUS Göppert.

Pl. LXXIII, Figs. 1–6.

1864. *Zamites arcticus* Göpp.: XLI. Jahresber. d. Schles. Ges. f. vaterl. Cult., p. 84 (nomen).

1866. *Zamites arcticus* Göpp.: Neues Jahrb. f. Min., etc., 1866, p. 134, pl. ii, figs. 9, 10.

1885. *Zamites* sp. Dn.: Trans. Roy. Soc. Canada, Sect. IV, Vol. III, p. 7, pl. i, fig. 4.

1898. *Zamites Weedii* Font. in Weed & Pirsson: Eighteenth Ann. Rep. U. S. Geol. Surv., 1896–97, Pt. III, p. 481. (Pl. LXXIII, Figs. 1, 4.)

A large number of imprints of a cycad were found at the Grafton and Geyser localities, which I can not by any essential features distinguish

from *Zamites arcticus* Göpp. Heer describes from the Kome beds of Greenland,[a] a number of specimens of this plant, and from the same beds a smaller form which he calls *Z. brevipennis*.[b] The latter, except in size, seems to be identical with *Z. arcticus* and has many features found in the Geyser plant. Indeed, the latter seems to give connecting links between the two, which make them difficult to separate. The Geyser specimens are preserved on a fine-grained shale, which gives details not to be seen on a coarser grained rock. This plant and *Nilsonia schaumburgensis* are much the most common fossils in the Geyser strata, and they are the plants most characteristic of them. Heer gives no nerves for *Zamites arcticus* and *Z. brevipennis*. The only difference that I can find between them and the Geyser plant is the greater size of the leaflets on some of the leaves of the latter, a point which in such cycads is of little importance. Besides, in the numerous Geyser specimens forms can be found which are similar in size to both *Z. arcticus* and *Z. brevipennis*. The description that Heer gives of these plants agrees closely with the characters seen in the Geyser plant. Heer himself, in his description of *Z. brevipennis*, gives as the only difference between it and *Z. arcticus* the smaller size of the leaves of the former and its shorter leaflets.

The number of imprints found in the Geyser beds and their good preservation enable me to add something to the descriptions given by Heer. There is some variability in the Geyser forms, some having wider leaflets and some narrower. Some of the leaflets from the same portion of the leaf are decidedly smaller than others, and the length of the leaflets from the middle portion of the leaves is shorter in some specimens than in others. But there are intermediate sizes that show that all belong to the same plant. Only fragments of leaves are seen, but some of these are 7 cm. long, showing that some at least attained considerable size, for these portions are from the middle part of the leaf and it does not change in width throughout the entire length. The midrib is broad and flat, being mostly hidden by the bases of the leaflets, which are attached upon its upper face. The leaflets diminish in length toward the base of the leaf, which indicates that, as is usual in cycadean leaves, they are supported in this case also by naked petioles. The opposite leaflets

[a] Flor. Foss. Arct., Vol. I, p. 82, pl. iii, fig. 14 [this is a copy of Göppert's fig. 9, see synonymy above]; pl. xliv, fig. 5c. Ibid., Vol. III, Pt. II (Kreide-Flora der Arctischen Zone), p. 67, pl. xv, figs. 6, 7.

[b] Ibid., Vol. III, p. 67, pl. xv, figs. 8, 9, 10.

on each side of the midrib are of equal length, are attached at right angles to the midrib, and stand at right angles to it. They are so closely placed as to touch one another, but sometimes, owing to pressure, which has forced the margins of the leaflets into the rock substance, they are made to appear narrower and hence farther apart. In shape the leaflets are of equal width from base to tip, with a linear form. They are rounded off at the free end so as to have a circular tip, or else are obliquely rounded on the lower outer margin of the tip, so that this margin has an elliptical outline. In all cases the extremity is very obtuse. At the end attached to the midrib the leaflet is truncate, with corners rounded. The leaflet appears to be placed on the upper surface of the midrib, with its base not fusing with the midrib, and terminates with a raised line, so that it appears superposed and adhering, showing the entire length distinct. The basis of leaflets on opposite sides are so closely placed that they almost touch. They are opposite or subopposite. The widest leaflets have a width of 4 mm. and the narrowest of 2 mm. The longest have a length of 12 mm. and the shortest of 6 mm. The leaf substance was thick and leathery, hiding the nerves. The nerves are slender and almost always invisible. They are seen only in the wider leaflets, where the leaf substance has been peeled off, leaving imprints of the nerves in the fine shale. Where seen they are 8 to 10 in number, but may be fewer in the narrower leaflets. They go off at right angles with the midrib and maintain the same angle, being strictly parallel.

Dunker[a] gives a description of a plant which he calls *Pterophyllum Lyellianum* that is very near to our fossil. Heer, in his description of *Zamites arcticus*,[b] says that this plant is so like *Z. arcticus* that it is difficult to give any distinction. The leaflets of Dunker's plant are only somewhat broader and farther apart. Dunker gives four to five very slender nerves as possessed by it. Heer rightly regards this not as a Pterophyllum but a Zamites of the type of *Z. arcticus*. Sir William Dawson, in his account of Kootanie plants,[c] describes forms of this type of cycad. One of these, pl. i, fig. 5, he identifies with Heer's *Z.acutipennis*. One he makes a new species, *Z. montana*, pl. i, figs. 6, 6a, and one he does

[a] Monogr. der Norddeutsch. Wealdenbildung, p. 14, pl. vi, figs. 1, 1a, 2.

[b] Fl. Foss. Arct., Vol. I, p. 82.

[c] On the Mesozoic floras of the Rocky Mountain region of Canada (Trans. Roy. Soc. Canada, Sect. IV, Vol. III), p. 7.

not identify or name, pl. i, fig. 4. The unnamed form, fig. 4, is strikingly like some of the Geyser plants and is probably the same species. *Z. montana* also is much like some of the forms from Montana, and the same may be said of his *Z. acutipennis*. Probably all are forms of *Z. arcticus*. It should be stated in this connection that in naming a Zamites from the Great Falls locality, *Zamites montanensis*, in my paper on "Some Fossil Plants from the Great Falls of Montana," it had escaped my notice that Dawson had previously named a Kootanie fossil *Z. montana*. These names are too much alike. Dawson states that *Z. montana* has four nerves, and he recognizes its closeness to *Z. arcticus* and to *Z. brevipennis*.

It is quite possible that *Z. borealis* Heer and *Z. acutipennis* are both forms of *Z. arcticus*, differing from it only in the somewhat longer leaflets. Heer gives four nerves for each of these. In all these Lower Cretaceous forms, *Pterophyllum Lyellianum* Dunk., *Zamites montana* Dn., *Z. borealis* Heer, and *Z. acutipennis* Heer, for which four nerves are given, the nerves are slender and immersed in the thick parenchyma of the leaflets; hence it is quite possible that they may have had more than four. From wrinkling in thick leaves of this type, owing to shrinkage along certain nerves, deceptive appearances are often given in the nervation. As it does not appear from the descriptions how distinctly nerves were seen in these plants, I hesitate, for those for which four nerves are given, to maintain their identity with *Z. arcticus*. Dr. J. S. Newberry, in an article describing some plants from the Great Falls coal field of Montana,[a] states that he recognized in these fossils Dawson's *Z. montana* and Heer's *Z. acutipennis*, and he describes an additional form, which he makes a new species, with the name *Z. apertus*. This he says is a small species resembling *Z. arcticus*, but is much more open in structure. The nerves are invisible, according to his statement. The figure (fig. 4) which Newberry gives of this plant does not show leaflets more distinct than those of *Z. arcticus*, which it closely resembles. It is probable that all of these forms are those of *Z. arcticus*.

It is to be noted that this type of cycad seems to be quite characteristic of the Kootanie beds of Canada and of the strata of similar age in Montana, forming a connecting link between the two floras. Cycads of this type have not been found in the Lower Potomac strata of Virginia, which have so many other forms that occur in the Mon-

[a] Am. Journ. Sci. for March, 1891.

tana beds. This form of cycad, which is so highly characteristic of the Lower Cretaceous, differs in so many essential points from the Zamites of the Jurassic, which find their type in *Z. Feneonis* (Brongn.) Ung., that it does not seem proper to unite them in one genus. If ever plants are to be made generically different from characters of foliage, it would seem that the Jurassic and Lower Cretaceous types of so-called Zamites ought to be so considered. As the form of the Lower Cretaceous is always and markedly pectinate in shape, *Pectinizamites* would appear to be a proper generic name.

Mr. Weed's collection contained a few forms of a Zamites that seemed from the imperfect specimens obtained to be new, and the name *Zamites Weedii* was proposed for it in the preliminary report. These are represented in Pl. LXXIII, Figs. 1 and 4. This collection showed also one or two imprints of a smaller Zamites, which, in the same report, was supposed to be a different species and compared with an unnamed Zamites of Dawson from the Kootanie of Canada. The numerous specimens of *Z. arcticus* above described show that both of these forms fall easily within the limits of variation of that species, and hence they must be regarded as identical with it.

Pl. LXXIII, Fig. 1, represents the basal portion of one of the leaves, with wider leaflets, and shows the shortening of the leaflets toward the base. No doubt lower down on the leaf the leaflets are wanting, giving a naked petiole. Fig. 2 shows a fragment of a leaf from its middle portion, with leaflets of the larger size, but not quite so large as some that were seen. Fig. 3 represents a small fragment from the middle portion of a leaf, showing some of the largest leaflets seen. Fig. 4 gives a small fragment of a leaf from its middle portion, showing leaflets of the smallest size. Fig. 5 represents a fragment from the middle portion of a leaf that shows the narrowest type of leaflets that possess an average length. Fig. 6 gives two of the leaflets of Fig. 5 enlarged four diameters to show details.

Genus CYCADEOSPERMUM Saporta.

CYCADEOSPERMUM MONTANENSE Fontaine n. sp.

Pl. LXXIII, Fig. 7.

A single nut-like seed was found in the Geyser beds, which seems to be a Cycadeospermum, probably a new species. But there is not

enough material to decide this positively. The seed is ovate-elliptical in form, 5 mm. long, and 3 mm. wide in its broadest portion. It has the smooth horny-looking epidermis characteristic of Cycadeospermum, and is wrinkled from shrinkage.

Order PINALES.

Family TAXACEÆ.

Genus CEPHALOTAXOPSIS Fontaine.

Cephalotaxopsis ramosa Fontaine?[a]

Pl. LXXIII, Fig. 8.

A number of imprints of detached leaflets were found on several pieces of the Geyser shale that closely resemble leaflets of *Cephalotaxopsis ramosa* Font., a plant found rather abundantly in the Lower Potomac beds of Virginia. None of these were found attached and they are all fragments of leaflets. Their texture is leathery, but rather thin for a Cephalotaxopsis, and they have a strong single nerve. They appear to be certainly leaflets of some Cephalotaxopsis, but are not well enough preserved and sufficiently abundant to disclose clearly their specific character. They agree best with the narrower form of leaflets of *C. ramosa.*

Genus NAGEIOPSIS Fontaine.

Nageiopsis longifolia Fontaine.

Pl. LXXIII, Fig. 9.

Five or six fragments of shale from the Geyser strata show imprints of pieces of strap-shaped leaflets with parallel nerves that have the character of *Nageiopsis longifolia* Font., a conifer found first in the Lower Potomac beds of Virginia. The imprints are all of fragments of leaflets, the longest being from 5 cm. to 6 cm. in length, with a width of 5 cm. or 6 cm. None of them are attached, but one specimen shows the basal portion of a leaflet with the characteristic narrowing seen in *N. longifolia,* which gives the base of the leaflet an elliptical from. This plant does not seem to be common in the Geyser strata.

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[a] For the synonymy f this species see p. 258.—L. F. W.

NAGEIOPSIS MONTANENSIS Fontaine n. sp.

Pl. LXXIII, Fig. 10.

A single imprint of a nearly entire leaf with the reverse was found in the Geyser beds that seems to be a new Nageiopsis. It is 2 cm. long and 8 mm. wide in its widest portion. Its shape is elliptical with an obtuse tip, and it narrows at the base to a pedicel. The nerves at the base of the leaf are sometimes once forked and sometimes single. They go nearly parallel to the tip of the leaf, where they are more crowded, but do not converge as in Podozamites. There is not enough material to determine certainly whether or not this is a new species of Nageiopsis, but I provisionally so regard it. It is like some of the leaves of *N. zamioides* Font., of the Potomac of Virginia, but is more obtuse and narrows to the base more gradually and more decidedly than the leaves of that plant.

Family PINACEÆ.

Genus LARICOPSIS Fontaine.

LARICOPSIS LONGIFOLIA LATIFOLIA Fontaine n. var.

Pl. LXXIII, Figs. 11–14.

1898. *Laricopsis longifolia* Font.? in Weed & Pirsson: Eighteenth Ann. Rept. U. S. Geol. Surv., 1896–97, Pt. III, p. 482. (Pl. LXXIII, Fig. 14.)

A large number of imprints of a conifer with narrow thread-like leaves occur in the Geyser specimens collected by Professor Ward and several in those obtained by Mr. Weed from the Grafton locality. They have the character of *Laricopsis longifolia* Font., a plant characteristic of the Lower Potomac of Virginia. The leaves, however, have on an average a greater width, being 1 mm. in width, while in the Virginia fossil they average only half as much. This greater width may, however, be due to the better preservation of the Montana specimens. The shale which carries these Montana imprints is very fine grained and shows the entire original width of the leaflets. The Virginia rock material is coarser, and the leaves whose imprints are shown on it appear to have suffered somewhat from maceration, which may have diminished their apparent width. But notwithstanding the sharpness of outline shown in the Montana specimens, the nerves are very obscure and not more distinctly shown than in the Virginia forms. There appears to be one in each leaf. The leaves are attached singly or in

bundles, scattered around the stem, and on falling off leave marks that are more or less circular in form. The original number of leaves in a bundle could not be made out, as in no case could it be determined whether or not all were preserved. The stems, in proportion to the size of the leaves, are always quite stout, a feature observed in the Potomac forms.

Pl. LXXIII, Fig. 11, shows a portion of one of the stems with the basal parts of some of the leaves still attached. The leaves are in all cases fragmentary, so that their original length could not be made out. Fig. 12 shows a portion of a principal stem and parts of several branches that go off as if they had originally formed a whorl, reminding one of the mode of branching of Cephalotaxopsis. Fig. 13 shows a stem with many leaves. Fig. 14 represents the specimen collected by Mr. Weed at the Grafton locality.

This plant seems to have been rather common in the Geyser beds and it is one of the most characteristic of their fossils. Conifers seem to be quite rare in these strata and this is decidedly the most common of them.

Besides the undoubted plant fossils found in the Geyser beds there are two forms of imprints that probably belong to some animal with a thin bivalve shell. They resemble most the imprints of the shells of Estheria. If they represent this genus, there are probably two species of it in the Geyser beds. Both are quite small. The larger one has a length of 11 mm. and a maximum width of 6 mm. This is represented by one specimen. The other shows three imprints. It is more nearly circular in form than the larger imprint and has dimensions 4 mm. by 6 mm.

SUMMARY AND CONCLUSIONS.

The list of plants found in the Geyser strata contains the following forms:

1. Dicksonia montanensis Font. n. sp.
2. Dicksonia pachyphylla Font.
3. Thyrsopteris elliptica Font.
4. Cladophlebis falcata montanensis Font. n. comb.
5. Cladophlebis heterophylla Font.
6. Cladophlebis constricta Font.?
7. Equisetum Phillipsii (Dunk.) Brongn.
8. Equisetum Lyellii Mant.
9. Lycopodites ? montanensis Font. n. sp.
10. Nilsonia schaumburgensis (Dunk.) Nath.
11. Zamites arcticus Göpp.
12. Cycadeospermum montanense Font. n. sp.
13. Cephalotaxopsis ramosa Font.?
14. Nageiopsis longifolia Font.
15. Nageiopsis montanensis Font. n. sp.
16. Laricopsis longifolia latifolia Font. n. var.

In drawing conclusions as to the age of this flora we may omit *Dicksonia montanensis, D. pachyphylla,*[a] *Nageiopsis montanensis, Lycopodites ? montanensis, Cycadeospermum montanense* as being new species or too imperfectly characterized. *Cladophlebis constricta ?* and *Cephalotaxopsis ramosa ?* also should be omitted as being not determined with positiveness. The remaining plants are not of equal value in fixing the age.

Equisetum Phillipsii, from its great abundance, has a high value. As is known, this is a Wealden form. *E. Lyellii* also is Wealden, but from its greater rarity and the possibility that it may be some portion of *E. Phillipsii* it has not so much weight. The *Cladophlebis falcata montanensis* is near enough to the Potomac form to be regarded as its representative modified by differences of environment. The Lower Potomac strata which contain the type form are shown by their flora to be Wealden in age. *Cladophlebis heterophylla* is a plant of the Great Falls beds, which have many forms in common with the Lower Potomac. *Thyrsopteris elliptica* occurs in too few specimens to have much value, as it can not, from the specimens, be regarded as a common and characteristic plant of the Geyser beds, but it strengthens the resemblance of this flora to that of the Lower Potomac.

Nilsonia schaumburgensis is of high value in determining age. It is an important and characteristic plant in the European Wealden flora, and its great abundance in the Geyser strata shows that it is one of the most characteristic for the Montana locality. Its occurrence there adds another, and a most important, form to those that Yokoyama had previously made known as common to the Lower Cretaceous flora of Japan and the United States. Its presence in the Geyser flora strongly confirms the conclusion that its age is Wealden. *Zamites arcticus*[b] also must be considered as one of the most characteristic plants of these beds. This type of Zamites not only indicates the Wealden age of the beds containing it but shows that they have elements characteristic of the Kootanie and the Great Falls formations.

Laricopsis longifolia latifolia is so near the type plant of the Lower Potomac that it may be regarded as its representative, and it gives

[a] Professor Fontaine was not aware at the time of preparing this report that this species occurred in the Shasta formation. It is found only in the lower or Knoxville member of that formation.—L. F. W.

[b] This also occurs in the Knoxville beds of the Shasta formation.—L. F. W.

another Lower Potomac element. The other form, *Nageiopsis longifolia*,[a] from the small amount of material that it shows, does not possess much value, but so far as its evidence goes it adds to the Lower Potomac a affinities.

We may conclude then fairly, I think, that these Geyser strata belong to the same formation with the Great Falls group of beds, and that the evidence of the Geyser fossils confirms the conclusion previously made by Doctor Newberry and myself, that the age of this group is Wealden, being essentially of the same age as the Lower Potomac of Virginia.

FLORA OF THE LAKOTA FORMATION OF THE BLACK HILLS.

Passing eastward, the next series of plant-bearing beds of the Lower Cretaceous that we encounter whose flora has been made known is that of the Black Hills in Wyoming and South Dakota. Before I began my investigations in 1893 these beds were regarded by all geologists as belonging to the Dakota formation, and it is therefore doubly unfortunate that Mr. Darton should have applied to them the name *Lakota*,[b] a name so closely resembling Dakota that typographical errors are unavoidable.

As I have already published[c] an exhaustive report on the Cretaceous flora of the Black Hills, chiefly on the flora of the Lakota formation, and as this report is as accessible to all persons interested as are the present papers, it is not considered necessary again to go over any of the ground covered by it. The bibliographical references are very full in that report, so that even these need not be repeated, and the record may be regarded as complete down to the end of October, 1898.

I was even able to embody in that paper (pp. 548–551) an account of my expedition to the Black Hills in October, 1898, in company with Mr. H. F. Wells, who had collected so many cycadean trunks for Professor Marsh, in the course of which we visited all the localities known to him. In both the Minnekahta and Blackhawk regions there were large numbers of specimens still lying on the ground, some of them as fine as any sent in,

[a] This Potomac plant has since been found to occur in the Jurasso-Cretaceous beds of Alaska.—L. F. W.

[b] Bull. Geol. Soc. Am., Vol. X, December, 1889, p. 387: Twenty-first Ann. Rep. U. S. Geol. Surv., Pt. IV, 1901, pp. 526–529. On p. 527 of the last-named paper he states that "the name Lakota is derived from one of the tribal divisions of the Sioux Indians."

[c] The Cretaceous formation of the Black Hills as indicated by the fossil plants: Nineteenth Ann. Rep. U. S. Geol. Surv., Pt. II, 1899, pp. 521–946, pl. liii–clxxii.

but most of them more or less fragmentary. The value of these fragments to science is, however, very great, and on my return I succeeded in inducing Professor Marsh to authorize Mr. Wells to finish the work he had begun by gathering them all up and shipping them to New Haven. This was done and the specimens arrived early in 1899. Meantime, in November, 1898, I went for the fourth time to New Haven and determined a collection of 44 specimens that Mr. Wells had sent since my last visit in June. It was then that I explained to Professor Marsh what I had seen in October and that he instructed Mr. Wells to send him all the cycads he could find. Knowing that these were coming I purposely left the work unfinished, certain that the new material would not only afford a much broader basis for the study of the collections, but would complete many of the imperfect trunks by supplying the missing parts. In this I was not mistaken. The great collection happily reached New Haven and was unpacked a month or more before the fatal illness of Professor Marsh, so that he was able to contemplate it in all its magnitude.

As stated in my paper on the flora of the Black Hills (p. 623), Professor Marsh had persuaded Mr. George R. Wieland to undertake the microscopic study of the fossil cycads in the Yale Museum, and he began his investigations near the beginning of 1899. He commenced publishing in March of that year, and four of his contributions, all based on the Black Hills material, have thus far appeared.[a] The series will doubtless be continued, and a monograph is announced. The work on the internal structure of American fossil cycads is thus fairly begun, the results are already highly important, and the possibilities seem practically unlimited.

On May 1, 1900, at the request of Dr. C. E. Beecher, I again visited New Haven and resumed the work of elaborating the cycad material. The collections now numbered over 700 specimens, but more than half of these consisted of the smaller fragments gathered from the field by Mr. Wells, who had previously neglected to send them, not supposing them worth preserving. I had emphasized their importance to Professor Marsh, and, as above stated, he had ordered their shipment. None of them are wholly without scientific value, especially in the study of their internal structure, and many of them were found to be the missing parts of broken trunks

[a] A study of some American Fossil Cycads, by George R. Wieland. Pt. I. Am. Jur. Sci., 4th ser., Vol. VII, May, 1899, pp. 219–226, pl. ii–iv; Pt. II, ibid., April, 1899, pp. 305–308, pl. vii; Pt. III, ibid., May, 1899, pp. 383–391, pl. viii–x; Pt. IV, ibid., Vol. XI, June, 1901, pp. 423–436.

previously received. I was able to refer the larger part of them to species already described with greater or less confidence. The residue remain indeterminable. I completed this work on May 15, and prepared an article embodying the results and describing the 7 additional new species, one of which, however, as we have seen (see pp. 203 to 204), has proved to be probably of Jurassic age and to belong to the genus Cycadella. The illustrations for this article were prepared by Doctor Beecher after my departure for Europe from memoranda which I furnished before leaving. The article did not appear until November.[a]

In addition to the matter relating to the Jurassic of the Black Hills furnished me by Mr. Wieland (see pp. 203–204), he has also sent me his notes on the Lakota obtained during his investigation of the hills the same season (1900). As these embody much new information relating to the flora of the Lower Cretaceous of the Black Hills, I gladly insert them at this place. They consist of trial sections for the study of the fossil faunas and floras of the formation, with appropriate discussion, and also contain the description and illustration of a new species of Nilsonia collected by Mr. Wieland.

NOTES ON THE STRATIGRAPHY AND PALEONTOLOGY OF THE BLACK HILLS RIM.

By G. R. Wieland.

The United States Geological Survey has for several years past engaged actively in the field investigation of the geology of the Black Hills, a region which has been recognized by all as of paramount scientific interest. Hence it might seem superfluous either to add to the various sections already published by Ward, Darton, and others, or in any way to anticipate the more extended publications of the Survey on this subject. But as it has been my good fortune to make extensive saurian and plant collections in the Black Hills rim country, and as many of these specimens are types of the highest interest and come from a series of localities girdling the Black Hills, my notes on the localities and horizons in which these fossils were secured may well be recorded.

It is well known that 5 or 10 vertical feet may be just as important from a biologic as from a stratigraphic standpoint. Far too often

[a] Elaboration of the fossil cycads in the Yale Museum, by Lester F. Ward: Am. Journ. Sci., 4th ser., Vol. X, November, 1900, pp. 327–345, pl. ii–iv.

important forms which may perhaps not be duplicated in a century are collected and described with but the most imperfect record of their locality and horizon. The accurate topographical and geological maps now being prepared will render this less and less likely to happen. In this connection I should say that Prof. Henry F. Osborn, of the American Museum of Natural History, throughout his extensive explorations in the Rocky Mountain country has insisted upon the value of the vertical record from the evolutionary point of view, and these notes have been in large part prepared while engaged in field work for the American Museum.

The general character of the sedimentary rocks of the Black Hills is well known—the high outer rim of fossil-bearing Jurassic and Cretaceous horizons, with the intervening eroded red Trias (or, as now seems more probable, Permian) valley extending entirely around the central mountain area of eruptive followed by Paleozoic rocks. I shall, then, at once give certain sections, not only of importance in the correlation of the "rim" horizons as they extend around the hills, because well marked by characteristic fossils, but also because of the great biologic interest of the faunal and floral relations here seen.

Three miles due north of Piedmont, S. Dak., near the middle of the eastern side of the Black Hills, there is a characteristic section of primary interest. The small knoll near which it is taken may serve to name it.

Section at the Saurian Knoll, 3 miles due north of Piedmont, S. Dak.

	Feet.
12. Fort Benton shales, with perhaps 100 feet of underlying strata not studied	129
11. Massive more or less cross-bedded sand rock, flesh colored, barren (?), and here forming the summit of the rim	60
10. Deeply iron-stained sandstone with much silicified wood, doubtless equivalent to the cycad-bearing horizon east of Piedmont, and at least in part to that of Minnekahta	20
9. Shale, gray to blue, with silicified wood	20
8. White soft sandstone	10
7. Sand rock, dirty white, granular, and containing Camptosaurus and other dinosaurs	2
6. An all-shale talus	60
5. Sand rock with two harder ledges	20
4. Shale and limestone layers containing numerous ostracods and occasionally fish teeth (Hybodus ?)	20
3. Prominent shale bed, from base of which Barosaurus, Morosaurus, and other large dinosaurs were collected, as well as much silicified wood	60
2. Shale with nodular layers, containing more or less imperfect remains of numerous large saurians	20
1. Drab to white sand rock, here much cross-bedded above (the Unkpapa of Darton)	75
Total	506

Marine Jurassic.

I should add that No. 3 is usually followed by light-colored sandstone containing indistinct remains of plants. These rarely become distinct.

Just east of Spearfish, S. Dak., there is such a locality requiring further examination, and on the outer rim, 16 miles north of the present section,[a] I secured fine specimens of a Nilsonia, which is a new species. It may be characterized as follows:

Genus NILSONIA Brongniart.

NILSONIA NIGRACOLLENSIS Wieland n. sp.

Pl. LXXIII, Fig. 15a–d.

While none of the fronds of the type specimen are complete, the parts present are numerous, and include bases, middle portions, and tips, showing both upper and lower surfaces, the venation of all being distinct. From these various portions we may conclude that the entire blades were probably 25 cm. in length. But they may perhaps have reached a length of 30 cm., and, as in the case of all characteristic Nilsonias, there is evidence of considerable variation in size.[b] As the base is long and tapering, the tip blunt, and the greatest width not more than 11 mm., the fronds were gracefully linear. Apparently, they were widest somewhere beyond their middle point. By placing the base *a*, the middle portion *b*, and the tip *c*, as shown in the figure, end to end, the general outline of a nearly complete frond (or pinnule) will be obtained.

As indicated in the figure, the midrib is distinct, but not heavy. The lateral nerves are normally simple and parallel, but very rarely they fork close to their origin. They rise only slightly just at their origin on the slender raised line marking the upper surface of the midrib, but more sharply at their tips, their general course lying quite uniformly at an angle of about 75° to the midrib. Both their direction and distance apart are quite constant from base to tip. There are from 23 to 26 lateral veins to the centimeter.

Locality and horizon.—This very characteristic new species receives its name from the Black Hills, being the first example of the Nilsonia-Tæniopteris form of frond to be reported from this region.

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[a] Both these plant localities lie at the base of Darton's Lakota sandstone.

[b] This is one kind of evidence in favor of the once pinnate character of many of the species of this and the related genera, which is not to be neglected; the differences in size as a varietal character, in the case of specimens from the same locality, is hence of doubtful value. Thus in *Nilsonia polymorpha* Schenk it seems to me the best explanation is that the multiform blades are the pinnæ of, not a bipinnate, but rather a bipinnoid frond of triangular outline.

The type specimen was collected near the summit of the Black Hills rim, 5 miles north of Sturgis, S. Dak., and has been presented to the Yale Museum. It consists of a small slab of fine-grained drab sandstone containing numerous imprints of portions of fronds or pinnules, with some fragmentary, but distinct, specimens of *Thyrsopteris dentifolia* Font.,[a] Pl. LXXIII, Fig. 15d, and was obtained *in situ* from the base of the first sandstone stratum which here overlies the Beulah shale, containing Jurassic dinosaurs. The horizon of the present new Nilsonia therefore belongs at the very base of the Lakota formation of Darton.

In considering the relationships of the present species I will explain that I at first referred it to the genus Tæniopteris of Brongniart, but on the reference of my manuscript by Professor Ward to Professor Fontaine the latter replied that he considered it a Nilsonia. This reply Professor Ward was so kind as to send me, and as it deals with the distinction between these very important genera, as well as with the only known American species of Nilsonia with which the Black Hills specimens may be directly compared, I give it in full. Professor Fontaine says:

> The supposed "Tæniopteris" of Mr. Wieland is an interesting plant. His figures and description indicate that it is a Nilsonia rather than a Tæniopteris. It seems that we can not insist on segmentation of the lamina of the leaf as a diagnostic character of Nilsonia, although the laminæ are generally segmented. This would leave as the only important difference between the two genera the fact that in Nilsonia the lamina of the leaf is attached to the upper surface of the midnerve, while in Tæniopteris it is attached to the sides. Hence in Nilsonia, on the upper surface of the leaf, the bases of the lateral nerves are inserted on a raised line or cord, running about the middle of the midnerve, which latter is inconspicuous. In Tæniopteris the lateral nerves are inserted on the sides of the midnerve, which is conspicuous. These Nilsonia features are very evident in Mr. Wieland's plant. This plant is strikingly like *Nilsonia parvula* (Heer) Font. of the Jurassic of Oregon. As, however, it is constantly larger and more robust than the predominant forms of that fossil, it is probably specifically different. It looks much like a modified descendant of *N. parvula*, the larger forms of which are fully as large as the smaller ones of *N. nigracollensis*. Heer made *N. parvula* a Tæniopteris, but the numerous Oregon forms show that it is a Nilsonia. As this plant was exceedingly abundant in the Oregon

[a] Described in Ward's Cretaceous Formation of the Black Hills (Nineteenth Ann. Rep. U. S. Geol. Surv. Pt. II, 1899, p. 660, pl. clxvi, figs. 6–9), from the Hay Creek region, Wyoming, as coming from "over coal 50 feet above the Jurassic." The main Aladdin Wyoming coal seam lies immediately over the shale numbered 3 in my section taken north of Piedmont, and hence in the same relative position.

Jurassic flora, it is to be expected that it would survive with modifications in the Lower Cretaceous. As the description of the Oregon Jurassic plants is unpublished, of course Mr. Wieland did not have an opportunity to compare the two. * * *

Among foreign specimens presenting analogies, that figured by Seward as *Tæniopteris Beyrichii* (Schenk) Sew.,[a] from the Wealden of Ecclesbourne, bears quite as strong a resemblance to the Black Hills specimens as any form known to me. It is broader, and the veins are not so closely set. I suspect that this plant is a Nilsonia.

Also, in his memoir on La Flore Wealdienne de Bernissart,[b] Mr. Seward figures bases of fronds which agree in size and form with our specimens. Unfortunately, their venation is lacking. Seward compares this form with *Tæniopteris* (*Oleandridium*) *Beyrichii* (Schenk) Sew.[c] This species is smaller and its veins sometimes fork, but the general resemblance to *N. nigracollensis* is marked. From Schenk's figures I should say that the insertion of the lamina is intermediate between the condition seen in characteristic Nilsonias where the laminæ extend to the center of the upper surface of the midrib and forms like *Tæniopteris vittata* Brongn., where the laminæ are inserted well down on the sides of the prominent midrib.

Lastly, I may mention *Nilsonia polymorpha* Schenk, so well and fully illustrated by Nathorst in four plates, comprising many figures of the beautifully preserved specimens from the Rhetic of Pålsjö, Sweden.[d] The smaller forms of these with whole margins bear a close resemblance to the Black Hill fronds, and we can not doubt their generic relationship.

As regards the generic distinction between Nilsonia and Tæniopteris, after again examining all the evidence now available to me, I agree with Professor Fontaine's view. It is to be borne in mind that the genera Nilsonia, Tæniopteris, and Oleandridium have now come to comprise numerous species of a very generalized and cosmopolitan type of leaf. As a consequence, it has become difficult, as always in such a case, to say definitely, in the absence of extended revision, where the one genus

[a] Fossil Plants of the Wealden, Pt. I, p. 127, pl. ix, figs. 3, 3a.

[b] Mém. Mus. Roy. d. Hist. Nat., Vol. I, Bruxelles, 1900.

[c] Palaeontographica, Vol. XIX, p. 221, pl. xxix, figs. 6, 7.

[d] Nathorst, Bidrag till Sveriges Foss. Fl.: Kongl. Sv. Vet.-Akad., Handlingar, Vol. XIV, No. 3, Stockholm, 1876, pl. viii–xi.

ends and the other begins.[a] Nevertheless, we have every reason to believe that at the one end of the series there are characteristic ferns analogous to such living forms as Oleandra and Acrostichum, as well as marattiaceous forms, and at the other an important list of cycadaceous forms. The closely related genera Pterophyllum and Anomozamites may be cited in this connection. *Anomozamites minor* (Brongn.) Nath., as restored by Nathorst from specimens from the Rhetic of Scania, with its Williamsonia-like fructifications, Nilsonia-like foliage, and branching habit, is especially to be mentioned in this connection as one of the most interesting fossil plants known.[b] This series is at the same time an exceedingly important one, covering as it does a period extending over much of the Paleozoic to the close of the Jurassic at least, a period so fertile in the evolution of higher forms.

Nilsonia nigracollensis occurs between the Jurassic beds yielding the genus Cycadella of Ward and that higher up from which he has described so many Cycadeoideas. This gives it as a probably allied plant much additional interest.

Perhaps next in interest to the sections already given is that at the so-called "Calico Canyon," near Buffalo Gap, South Dakota, so named from the beautifully banded sandstone there quarried. This section is as follows:

Rim section on the northern slope of Calico Canyon near Buffalo Gap, South Dakota, beginning in the banded sandstone quarry, and extending from the marine Jurassic to the Fort Benton.

	Feet.
34. Fort Benton shales.	
33. Light-colored sandstone	10
32. Various shaly or sandy layers	40
31. Heavy and prominent bed of flesh-colored sand rock capping the escarpment and containing some silicified wood	50

[a] In this connection the following remark of Nathorst (op. cit., p. 42) is of interest:

"*Nilsonia polymorpha* Schenk is considered by Saporta, as well as by Schimper, to be so closely related to *N. brevis* and *N. elongata* of Brongniart that both the latter species may perhaps be only varieties of it. A specimen from the gray shales of Pålsjö (Swedish Rhetic) may at first sight give some support to this view. Such as have entire margins have a habitual Tæniopteris form. For this reason Count Saporta verbally suggested the idea that *N. polymorpha* possibly included a Tæniopteris. The Pålsjö specimens with well-preserved margins show, however, that this is not the case, a fact which Saporta later admitted in writing. The nervature as above described is characteristic of Nilsonia, with simple lateral nerves, while these nerves in *Tæniopteris* are dichotomously branched at the base. Nevertheless, there occur, as stated, transitions from the one form to the others."

I need only remark that as we can not rely on form, and as we now know we can not separate these genera on the basis of dichotomy of the lateral veins, there is, in the absence of a knowledge of their fructification, no very positive means of separation.

[b] Nathorst, Nya Anmärkningar om Williamsonia: Öfv. Kongl. Svensk. Vet.-Akad. Förh., pp. 359–365. Stockholm, 1888.

	Feet.
30. Light-colored clayey sand rock	15
29. Ledge of grayish to dark mud rock	8
28. Band of shale.	
27. Light-colored sandstone	5
26. Shale	20
25. Light-colored clayey sand rock a little more indurated than No. 23	6
24. A clayey layer	15
23. Fragile light-colored sand rock	15
22. Dark shale	30
NOTE.—Nos. 22, 24, and 26 seem to have been due to similar conditions of deeper water alternating with those forming the sandstone layers Nos. 23, 25, and 27.	
21. A layer of rock much like Nos. 17 and 19, but forming a sharper ledge	6
20. A shale talus	50
19. Grayish sand rock tending to form a ledge	5
18. Shaly sandy material, yellowish and more clayey above	25
17. Much like No. 19	5
16. Dark-colored shales	15
15. Heavy ledge of drab sandstone	15
14. Soft rock or shale, followed above by a well-marked shale or clay	50
13. Ledge of sand rock	10
12. Soft rock weathering out rather gray and shaly	15
11. Light-colored ledge of sand rock with obscure plant impressions and frequent remains of dinosaurs [Stegosaurus and others] and silicified wood. As noted in the field, No. 11 is 80 or 90 feet above No. 3	8
10. Shaly layer	3
9. Soft flesh-colored sand rock	8
8. Shale	1
7. Rather soft sand rock forming a ledge	12
6. White sandstone, very soft, or else in places splitting into small and irregular blocks	12
5. Soft sandstone or shales	15
4. A layer of sand rock sometimes forming a continuous ledge with No. 3	12
3. Cross-bedded sandstone with silicified wood and frequent dinosaurian remains, especially in the lower part, somewhat conglomeratic. Forms a distinct ledge	12
2. Light-colored to white sandstone with some banding, ochreous in places	50
1. Highly colored sandstone of the Calico Canyon quarry	60
Total	613

NOTE.—Nos. 1 and 2 constitute Darton's Unkpapa. They are very variable in thickness. No. 2 is sometimes followed by shale instead of sandstone. Whether or not this shale corresponds to that bearing dinosaurian remains, as at Piedmont, Sturgis, and other points, is a question, though such may be the fact. I am unable to place the Piedmont and Minnekahta cycad horizon in this section, though it must be present somewhere above No. 11, the uppermost of the two dinosaur horizons.

With regard to the horizon of the Minnekahta cycads much has been said, but the following section includes some additional facts. In it Nos. 3–6 are in the general position of the Beulah shales.

Red Canyon Creek section (South Basin), 4 miles southwest of Minnekahta, taken at a point about one-fourth mile south of Matties Peak.

	Feet.
13. A series of rocks nearly repeating the character of Nos. 6 and 9 of this section, with some silicified wood, though too much covered by talus to be readily divided	80
12. Light flesh-colored sandstone, in places reddish, containing silicified wood and probably some cycads	20
11. Characteristic red to yellowish sandstone, with cycads and large silicified tree trunks, which may in part be Araucarioxylons, also fragments of saurian bones	20

	Feet.
10. Shale bed (or clays) below the cycad level	35
9. A layer of light-colored sandstone	12
8. Sandy shaly material	30
7. Sandstone	60
6. Shale much like No. 3	65
Nos. 3–6 make a somewhat homogeneous series about 125 feet in thickness.	
5. Same shale in character as that seen just below (4)	2
4. Sandstone breaking up into large blocks	6
3. Shale with nodular layers followed by very shaly material	45
2. Marine Jurassic (Belemnite horizon)	125
1. Red beds.	

The preceding section may be supplemented by the following briefer one, introduced merely to explain in a general way the continuation of the thus far barren horizons, save for silicified wood, here forming the summit of the rim:

Section at Parkers Peak, rising 200 feet above the cycad horizon and about 100 feet above Matties Peak.

	Feet.
4. A highly characteristic quartzitic cap, forming, through its peculiar erosion about the head of Hells Canyon, 2 miles east of the peak, picturesque pine-clad mesas	80
3. Softer sandstones, mostly talus-covered; basal portions form mesas east of Parkers Peak	50
2. Soft flesh-colored sand rock (pinkish or whitish), forming cliff	50
1. There should follow closely the red and yellow rock, followed beneath by the blue shale, between which two horizons are many of the cycads. At the head of the trail, 2 miles east of Arnold's ranch there is a distinct blue clay contact with the yellow cycad sandstone, and much silicified wood is present.	

There is occasional fossil wood on the tables mentioned in No. 3, and there is a presumption that they correspond to certain high tables on the southern side of "Calico Canyon," which are about 100 feet below No. 31 of that section and bear large quantities of silicified logs.

In conclusion, I give a section from the extreme northern hills, obtained at the office of the Aladdin (formerly Barrett) Coal Company, and called by them the Bore Hole B section. Being the result of a boring, it is most interesting to compare this section with that given by Mr. Walter P. Jenney on page 582 of Ward's Cretaceous Formation of the Black Hills. These sections are from the same point, Jenney's being the result of a surface examination of the finely exposed rim escarpment, and this section the record of a boring. Whoever will take the pains to compare these two sections will realize how difficult it is to correlate and reconcile the sections of different observers in the case of a highly developed series of sedimentary rocks like that of the Black Hills rim in the absence of positively identified fossils collected with care from horizons

numbered by the collectors. It shows the immense labor which yet remains to be done in completing and revising the geological history of the Black Hills rim.

Section from "Bore Hole B" at Aladdin, Wyo., beginning near the base of the Atlantosaurus shales, which may here be 100 feet thick.

	Feet.
8. Gray sand	45
7. "Black Jack" (carbonaceous or iron-stained clay and sand)	2
6. Brown sandstone (contains two hard and sharp ledges)	30
5. Red sandstones	7
4. Gray sandstones	122
3. Dark shaly clay, or the coal horizon lying over the Atlantosaurus shales proper	4
2. Green shaly clay of the Atlantosaurus shale proper	67
1. Nodular bed, also saurian-bearing Unkpapa sandstone	20

The latest contribution to the subject now under consideration that I am able to record is the elaborate paper of Mr. N. H. Darton,[a] published in 1901 and giving the results of his work in the Black Hills, mainly in the seasons of 1898 and 1899. The hydrographic part of this paper does not, of course, concern us here, and in his geological work Mr. Darton has paid little attention to paleontology, especially to paleobotany, but there are certain facts relating to fossil plants that he could not wholly ignore. He has not, however, contributed anything new to this subject, unless it be a sketch (pl. lxxvi, facing p. 526) of the large silicified trunk and stump described on page 552 of my paper on the Black Hills.[b] If the sketch is correct it would seem that a number of large segments from the middle portion have been removed since I was there. Mr. Darton has reproduced my plate lxxx (op. cit.) illustrating the most beautiful of the cycadean trunks, *Cycadeoidea pulcherrima*, which forms his plate lxxvii, but he does not give the name of the species or state to what genus these trunks belong.

The only interest, therefore, that this paper possesses for the paleobotanist is its geological part. It is here that for the first time he describes the Lakota formation, named by him in 1899 (see p. 315). This formation is treated on pages 526–529, but out of the Lower Cretaceous included in my sections, and extending from the Jurassic to the Dakota, he makes three formations, viz, the Lakota, the Minnewaste limestone,

[a] Preliminary description of the geology and water resources of the southern half of the Black Hills and adjoining regions in South Dakota and Wyoming, by Nelson Horatio Darton: Twenty-first Ann. Rept. U. S. Geol. Surv., Pt. IV, 1901, pp. 489–599, pl. lviii–cxii.

[b] Nineteenth Ann. Rep. U. S. Geol. Surv., Pt. II, 1899.

and the Fuson formation. This last immediately underlies the heavy quarry sandstone which he includes in the Dakota formation.

On page 527 Mr. Darton mentions his discovery of saurian bones "in the middle of the Lakota formation, or about 90 feet above the unconformity of the Unkpapa sandstone, which is approximately the horizon that has yielded cycads in the region between Edgemont and Minnekahta, near Blackhawk, and elsewhere about the hills." Commenting on this fact, he says: "If it were not for the evidence of the flora these bones would be regarded as late Jurassic in age. They will soon be described by Dr. F. A. Lucas, of the United States National Museum." They have now been described and the species is named *Stegosaurus Marshi*.[a] Mr. Lucas makes no reference to the age except in the title, but if the dermal spine found by Mr. J. B. Hatcher in the Triceratops beds belongs to this species it ranges entirely through the Cretaceous. Mr. Darton's remark, therefore, quoted above, is scarcely justified in the present state of knowledge.

FLORA OF THE TRINITY FORMATION.

Petrified wood is always the first form in which vegetable remains are observed in any country where it occurs, the discovery of the impressions of leaves, stems, fruits, and flowers being reserved for the close observations of the geologist and paleontologist when they chance to visit the region. It was so in Texas, and the record of the observation of silicified wood dates back at least to 1841. Mr. William Kennedy, in his work on Texas[b] of that date, mentions this fact in the following terms:

> In the middle and northern sections of the district lying between the Trinity and Neches rivers, great numbers of petrified post oak lie imbedded in the soil, some in a horizontal position, but the larger portion nearly upright, with an inclination toward the north. They are extremely hard, giving fire to steel; generally of light-gray or reddish-brown color, and present distinctly the form of the trunk of the post oak, even to the knots.

There is, of course, no certainty that the fossil wood here referred to belonged to the Trinity formation, as it is found at several horizons in

[a] A new dinosaur, *Stegosaurus Marshi*, from the Lower Cretaceous of South Dakota, by Frederic A. Lucas: Proc. U. S. Nat. Mus., Vol. XXIII, 1901, pp. 591–592, pl. xxiii, xxiv.

[b] Texas: The Rise, Progress, and Prospects of the Republic of Texas, in two volumes, by William Kennedy, esq., London, 1841, Vol. I, pp. 119–120.

Texas, but the locality seems to correspond to the Upper Cross Timbers, and the Trinity sands occur through the general region described. The description of the wood is wholly fanciful and only reflects the prevalent belief that the petrified wood belongs to the same trees that now grow in the region where it occurs. Kennedy goes on to say that personally he believes the wood to be only such living trees incrusted with calcareous [sic] matter in springs and mineral waters, all of which only emphasizes the undeveloped state of the science of fossil plants and the progress that has been made during the six decades that have elapsed since this was written, at least in this country.

Only a short time after this an eminent German geologist and paleontologist, Dr. Ferdinand Roemer, came to America and joined the little German colony that settled at New Braunfels, now the county seat of Comal County, Tex. He immediately commenced making geological observations in Texas and published his first paper in 1846.[a] He describes the fossil wood and admits that it is not that of the oak, but thinks that it is dicotyledonous and not coniferous, although from Cretaceous strata. In his second paper[b] he says:

> When I wrote my former paper I was not sure about the formation in which this fossil wood was originally deposited. I am now perfectly convinced that it is derived from Cretaceous strata, having afterwards found pieces of it among Cretaceous fossils at localities where for hundreds of miles around there are none other but Cretaceous strata, and no traces of diluvium or drift are met with.

In 1849 Roemer published in German a popular work on Texas,[c] in which he deals with the fossil wood somewhat more fully, both in the text (pp. 229, 230) and in the appendix (pp. 369, 370). He had sent specimens of it to Prof. H. R. Göppert, in Breslau, who had studied its internal structure and found some of it dicotyledonous and some coniferous. The latter he referred to the genus Pinites. A large Cretaceous fauna is described in the appendix. In his map the Cretaceous is shown to occupy a wide belt northwest of a line which is nearly a prolongation in both directions of one drawn through the cities of Austin and San Antonio.

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[a] A sketch of the geology of Texas, by Dr. Ferdinand Roemer: Am. Journ. Sci., 2d ser., Vol. II, November, 1846, pp. 358–365.

[b] Op. cit., Vol. VI, November, 1848, pp. 21–28.

[c] Texas. Mit Rücksicht auf deutsche Answanderung und die physischen Verhältnisse des Landes nach eigener Beobachtung geschildert, von Dr. Ferdinand Roemer. Mit einem naturwischenschaftlichen Anhange. Bonn, 1849, 464 pp. 8°. Topographisch-geognostische Karte.

Three years later appeared his illustrated folio work[a] on the geology and paleontology of the Cretaceous of Texas. All the fossils known to him at that time are here described and figured. Very little attempt is made to subdivide the Cretaceous or to work out the stratigraphy, and the fossils are regarded as indicating an Upper Cretaceous age, above the Gault and corresponding to the Senonian and Turonian of d'Orbigny. Specimens of fossil wood that he had sent to Dr. Franz Unger, in Vienna, were determined by the latter and briefly described without illustration on pages 94–95. Three genera were represented, two of which were dicotyledonous and came, as Roemer admits, from the Tertiary, but the *Thuyoxylum americanum* Ung. was collected between New Braunfels and Austin in the Cretaceous. It may have come from the Trinity sands.

The work of the Shumards, done between 1855 and 1860, but not published till 1886,[b] gives very little information relative to the Lower Cretaceous, and, as Mr. Hill remarks, they "place the bottom of the Texas strata on top, the top in the middle, and all the other subdivisions equally out of place."[c]

In one of B. F. Shumard's articles[d] he gives (p. 583) a section of the Cretaceous, which was made the subject of a critical review by Mr. Jules Marcou,[e] in which (p. 93) he introduces his own section, which Mr. Hill characterizes as "an approximately correct ideal section."[f]

Mr. S. B. Buckley devotes a few pages of his report[g] to the Cretaceous, but, as is usual with geologists, confines himself to the beds in which abundant molluscan remains occur. The sand rock near Weatherford, however, described on page 67, undoubtedly belongs to the Trinity, but he does not mention fossil wood nor any organic remains.

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[a] Die Kreidebildungen von Texas und ihre organischen Einschlüsse, von Dr. Ferdinand Roemer, Bonn, 1852, 100 pages, 11 plates fol.

[b] A Partial Report on the Geology of Western Texas, consisting of a General Geological Report and a Journal of Geological Observations, etc., by Geo. G. Shumard, Assistant State Geologist of Texas, Austin, 1886. Also several articles by G. G. and B. F. Shumard.

[c] Am. Journ. Sci., 3d ser., Vol. XXXIII, January, 1887, p. 75.

[d] Observations upon the Cretaceous strata of Texas: Trans. Acad. Sci. St. Louis, Vol. I, No. 4, 1860, pp. 582–590.

[e] Notes on the Cretaceous and Carboniferous rocks of Texas: Proc. Boston Soc. Nat. Hist., Vol. VIII, May, 1861, pp. 86–97.

[f] Am. Journ. Sci., 3d ser., Vol. XXXIII, January, 1887, p. 75.

[g] First Ann. Rep. Geol. and Agric. Surv. Texas, by S. B. Buckley, State geologist, Houston, 1874, pp. 65–69.

Mr. Robert T. Hill, who had had the advantage of a number of years' residence in Texas, studied its geology with great care and worked out the stratigraphical relations of the beds with much greater exactness than any of his predecessors. To him, in fact, we are indebted for the first correct section. After joining the staff of the United States Geological Survey as chief assistant to Dr. C. A. White, his work was verified by the latter, who went personally over the ground.

In February, 1887, Doctor White published a paper[a] giving the results arrived at so far as the Cretaceous was concerned. In the section given on page 40 of that paper the Comanche series is recognized and the lowest bed is called the "Dinosaur sands." It is described by Mr. Hill, who, as Doctor White states, wrote "the remarks at the right-hand side of the column," as "coarse silicious sand, popularly called 'pack-sand.' Occurs between the base of the fossiliferous Cretaceous and the Carboniferous series. Contains vertebrate remains."

In April of the same year appeared Mr. Hill's paper[b] on the Cross Timbers, with his own much fuller section of the Cretaceous of Texas (pp. 298–299). It is the same in its more general features as the section given in Doctor White's paper, except that Shumard's name "Austin limestone" is substituted for the name Dallas limestone; but much fuller historical, stratigraphical, and paleontological data are here given. The term "Dinosaur sand" is still retained for the basal beds representing the Upper Cross Timbers. The Lower Cross Timbers are shown to occupy a belt at the base of the Upper Cretaceous, which, therefore, practically corresponds to the Dakota formation. In these sections the whole of the Comanche series is shown to be Lower Cretaceous and the basal sands to be at the boundary line between the Cretaceous and the Jurassic.

Six months later Mr. Hill published a second paper on the Texas Cretaceous,[c] further discussing the stratigraphical relations. On pages 305–306 of this paper he says:

> The basal or Dinosaur sands of my section, which are interpolated between the Fredericksburg division and the undoubted Carboniferous, are the shore detritus

[a] On the Cretaceous formations of Texas and their relation to those of other portions of North America, by Charles A. White: Proc. Acad. Nat. Sci. of Philadelphia, 1887, pp. 39–47.

[b] The topography and geology of the Cross Timbers and surrounding regions in Northern Texas, by Robert T. Hill: Am. Journ. Sci., 3d ser., Vol. XXXIII, April, 1887, pp. 291–303, pl. vi (map).

[c] The Texas section of the American Cretaceous, by Robert T. Hill: Am. Journ. Sci., 3d ser., Vol. XXXIV, October, 1887, pp. 287–309.

of the Mesozoic sea when it bordered upon the Carboniferous continent. The lowest marine fauna of this division is seen in Parker County and careful study of the same may prove Jurassic affinities.

Mr. Hill extended his observations into Arkansas and Indian Territory, cooperating with the State Survey of Arkansas and contributing to its reports. He found that the basal sands extended into that State, and he traced them as far as he could find them. In a short preliminary paper[a] published in Science, at the beginning of 1888, he first named the Trinity formation. He briefly describes and locates it in both Texas and Arkansas, and says: "In Texas I found what are at present supposed to be dinosaurian remains, and occasional vegetal remains are met with," and adds: "To the continuous formation the name of 'Trinity' is applied, from the rivers of that name which arise in it. This includes the strata which I termed 'Dinosaur sands' in my Texas section."

It was, however, principally in his extended paper in the Annual Report of the Geological Survey of Arkansas for 1888[b] that he fully set forth the relations of these beds. They are here called the Trinity division of the Comanche series. He gives them a thickness of over 400 feet and says that in Texas "innumerable contacts between this formation and the base of the Comanche series have been seen by the writer and prove that it is below and older than our oldest Cretaceous (p. 124). * * * In Texas and Indian Territory the westernmost beds are beneath the Neocomian. Reviewing the stratigraphic evidence afforded by the Trinity formation it seems to be clearly older than any Cretaceous rocks hitherto described in this country, a fact which is verified by the paleontology, as shown in the next chapter" (p. 125).

The paleontology given is almost exclusively molluscan, the supposed vertebrate remains not having been as yet determined, and the plant remains being for the most part indeterminable, notwithstanding his reference to them as "abundant." They were referred to Dr. F. H. Knowlton, who reported briefly upon them in a letter which Mr. Hill publishes on page 152. The problematical form to which Doctor Knowlton refers was subsequently described (see p. 340).

[a] The Trinity formation of Arkansas, Indian Territory, and Texas, by Robert T. Hill: Science, Vol. XI, January 13, 1888, p. 21.

[b] Neozoic geology of southwestern Arkansas, by Robert T. Hill, assistant geologist: Ann. Rep. Geol. Surv Arkansas for 1888, Vol. II, 1888, pp. 1–354. See pp. 116–152.

In the section which occupies pages 188 and 189 he places the Trinity division in the Upper Jurassic, although in Chapters XI and XII he had called it Lower Cretaceous and included it in the Comanche series.

This latter view seems to have been his maturer judgment, for in the section which he introduces into his Annotated Check List,[a] published a year later, he does this systematically and has since consistently adhered to this classification.

Very little additional information relative to the Trinity formation is given in Mr. Hill's contribution to the First Annual Report of the Geological Survey of Texas,[b] which bears date 1890, and the section on pages 132–133 conforms to the one last mentioned.

In a paper read by Mr. Hill before the Geological Society of America on December 30, 1890,[c] and published in its bulletin, several important new features are introduced. The one which most concerns the present discussion is the recognition by Mr. Hill of an upper subdivision of the Trinity overlying the basal sands and consisting of alternating beds which he calls the Glen Rose beds. These are quite fully described and appear to have been previously included in his Fredericksburg division. In concluding his account of them he says:

> The different lithologic and stratigraphic features of the Glen Rose alternating beds, their position beneath the Fredericksburg division (separated in the north by a sandy, littoral terrane), and the entire absence of the great characteristic fauna of the hitherto recognized Fredericksburg division, entitle these beds to a distinct position, although they are separated by no structural unconformity.

Another new feature added in this paper is the Paluxy sands, which he here places at the base of the Fredericksburg division and describes on pages 510–511, and remarks that "no fossils have been found in the Paluxy sands save silicified wood, which occurs in great abundance and has been mistakenly considered Quaternary in age."

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[a] A preliminary annotated check list of the Cretaceous invertebrate fossils of Texas, etc., by Robert T. Hill: Bulletin Geol. Survey, Texas, No. 4, Austin, 1889, p. xiv.

[b] A brief description of the Cretaceous rocks of Texas and their economic uses, by Robert T. Hill: First Ann. Rep. Geol. Surv., Texas, Austin, 1890, pp. 105–141.

[c] The Comanche series of the Texas-Arkansas region, by Robert T. Hill: Bull. Geol. Soc. Am., Vol. II, May 5, 1891, pp. 503–528.

Doctor White's Cretaceous correlation paper[a] appeared in 1891, in which the Texan region is treated at some length. He recognizes the Trinity division, but does not subdivide it. He makes it coordinate with and not a part of the Comanche series, and considers that the latter is separated from the former by a hiatus. Both Doctor White and Mr. Hill continued erroneously to correlate the Trinity with the Tuscaloosa.

It was in 1891 that, on my return from Mexico, I visited the Lower Cretaceous areas of Texas and Arkansas, guided at first by Mr. Hill, who, however, was obliged to return to Washington before I had completed my investigation. We examined the Arkansas beds first, arriving on October 5 at Centerpoint, in Howard County, and working three days in the Trinity belt that stretches across that part of the State from east to west. Near the old Fort Towson road north of Centerpoint is a lignite bed belonging to the Trinity. The lignite is identical with that of the Potomac formation in general appearance, mode of preservation, and character of fracture. With it occur jointed stems of *Frenelopsis varians* subsequently described from Texas by Professor Fontaine. By far the best exposure found was that of Plaster Bluff, a great gypsum cliff on the right bank of the Little Missouri River, 3 miles south of Murfreesboro, Pike County. About 80 feet of the Trinity are here exposed, overlain by 30 feet of superficial deposits. Vast quantities of lignite occur above heavy beds of variegated clays greatly resembling those of the Potomac formation in Virginia. Above the lignite beds are the alternating marine shell-bearing beds, which are also gypsiferous. The lignite bed contains considerable vegetable matter, chiefly black fragments of stems, similar in all respects to those found farther west. *Frenelopsis varians* Font. was the most common form and most of the impressions were indeterminable.

The principal collection was made at Plaster Bluff, and this was sent to Professor Fontaine, but not at the same time as the collection from Glenrose, Tex., presently to be mentioned. I did not suppose there was anything determinable in the Plaster Bluff material, and placed it in a drawer. Several years later it was sent to him along with

[a] Correlation papers, Cretaceous, by Charles A. White: Bull. U. S. Geol. Surv. No. 82, 1891. See pp. 114–130.

a large amount of other Lower Cretaceous, chiefly Potomac, miscellaneous material, and he reported upon it at the time that he sent on his report on the Potomac flora of Virginia and Maryland, in November, 1902. In this report he says:

> About 50 rock specimens occurred in the collection from Plaster Bluff. The material is a fine-grained, lumpy shale, light ash-gray to nearly white in color, which has no cleavage. The shale, or rather the indurated clay, is full of small bits of vegetable matter, most of which are much comminuted and not identifiable. The only fossil that can be certainly identified is *Frenelopsis varians* Font., a plant characteristic of the Glen Rose beds of the Trinity group in Texas. This plant here shows only the internodes of the twigs, rarely more than the length of one internode being found in any one bit. The twigs seem to have been broken at the joints. Hundreds of these fragments are embedded in the clay. The firm, durable epidermis seems to have preserved very well the fragments, some of which are very distinct, showing the rows of minute tubercles on the surface, and the peculiar teeth-like leaves at the nodes. There is no doubt whatever that the twigs are jointed. A few bits in the clay suggest the presence of *Pagiophyllum dubium* Font., another characteristic plant of the Glen Rose beds. The fragments are, however, too obscure to be positively determined.

We next proceeded to the typical localities in western Texas, arriving at Glenrose, in Somervell County, on October 9. We had secured an outfit the previous day at Granbury, Hood County, and were thus enabled to study the formations passed over in traveling south to Glenrose. After passing Comanche Peak we entered the Paluxy sands, in which quantities of silicified wood occur. A citizen of Glenrose, Mr. J. W. Harvey, formerly of Cincinnati, where he had made collections from the Cincinnati group, had been active in collecting the shells of the country and had made a museum of his house. Besides the rich local fauna, he had a few vegetable impressions that interested me much. The locality at which they were obtained was on the Paluxy River 2 miles above Glenrose, and on the following day Mr. Harvey guided the party to the place and the day was spent in collecting the plants and associated animal remains. The bed lies in the Glen Rose limestone, and characteristic marine fossils of that group occur immediately above and below the plant layer. It is a white argillaceous limestone, cleaving in smooth layers which are rather thick. The plants occur throughout these layers. The matrix is fine grained and well adapted to preserve them, but tends to break across with a somewhat conchoidal fracture. It was obvious

at a glance that the plant remains had been floated some distance and become considerably macerated, so that only the thicker parts were preserved—stems, twigs, cones, etc. The more delicate organs and parts had disappeared entirely. Still, from the nature of the flora these thicker parts proved sufficiently characteristic to afford a fair idea of the principal types. Conifers predominated and the same jointed stems observed in the Arkansas Trinity were here much better preserved. These, as stated, represented the genus Frenelopsis. Tolerably well-preserved cones also occurred. Cycadaceous leaves were common, and a small Williamsonia, also a slender Equisetum. We did not have facilities for quarrying farther into the rock, and as Mr. Harvey had done a good deal of this kind of work, and as certain seams inaccessible to us promised better specimens, I engaged him to work the beds thoroughly, make as large a collection as possible, and ship it to Washington.

Just above the plant-yielding stratum is one of rougher material containing shells, and covered with stems resembling fucoids, some of which, however, may be the larger branches of coniferous plants. Considerable lignite also occurs in connection with these.

Three miles farther up the Paluxy occur extensive beds of a remarkable fossil, also common elsewhere at this horizon, which Mr. Hill had called Goniolina,[a] a genus that Saporta and Marian had referred to the vegetable kingdom.[b] Mr. Hill in his Preliminary Check List, cited above (p. XVIII), had referred to this fossil as "the peculiar globular foraminifera-like form, which has been called Gadolina by d'Orbigny," the word "Gadolina" being a misprint for Goniolina.

I spent considerable time in collecting representative specimens of this form, and especially in studying its relation to the fucoid-like objects with which it seemed to be always associated. Long, sinuous, and branching stems lying in relief on the rocks, but containing no trace of vegetable matter, have these spherical bodies lying beside them at irregular intervals, strongly suggesting an original organic attachment; but no actual attachment could be made out, though specimens were collected in which the two cohere. This, however, may be accidental. These

[a] Occurrence of Goniolina in the Comanche series of the Texas Cretaceous, by Robert T. Hill: Am. Journ. Sci., 3d. ser., Vol. XL, July, 1890, pp. 64–65.

[b] L'Evolution du Règne Végétal. Les Phanérogames, Vol. I, Paris, 1883, pp. 247–249.

fucoidal stems seem to be different from the larger and shorter branching objects which I was at the time inclined to refer to some coniferous plant.

While on the subject of this problematical form, the vegetable nature of which is, to say the least, still very doubtful, it may be well to review its history. Mr. Hill was under the impression that he was the first to discover it in the Cretaceous of Texas, and his first published mention of it was that above quoted in his Check List in 1889. This occurs in his geological introduction, and it is not included among the fossils of the Annotated Check List, which is confined to recognized animal forms that admit of systematic classification. In his paper, also above cited, on the Occurrence of Goniolina in the Comanche Series (1890), he gives its range as beginning "in the Colorado River section at the first (lowest) fossiliferous horizon in the basal Fredericksburg bed above the Trinity sands, and ranging upward through 450 feet of sediments into the base of the Comanche Peak chalk." He had sent specimens to "various paleontological friends in the scientific centers of the East, all of whom pronounced them an undetermined species of the genus Goniolina, of D'Orbigny."

He again mentions it in his Comanche series of the Texas-Arkansas region (1891), as "the large, strawberry-shaped Goniolina or Parkeria" (p. 508).

In a paper read before the Biological Society of Washington on January 28, 1893,[a] Mr. Hill discusses this form in the light of his latest observations, and especially of those made in the Glen Rose beds on the occasion of our visit above described, and on p. 39 he describes it, classing it under "Plantæ" and calling it an "undetermined species ('Goniolina'? of author's previous writings)." In the discussion, however, he says:

> A careful study in situ of the surface of a stratum in which these seams were well exposed showed that they branched very much like coniferous plants. At the termination of each ramification was found one of the small spherical casts, as if the limb of a plant laden with cones had been buried in the mud and its cast preserved. Recently, however, the fruit structure has been determined in the specimens themselves as figured on plate i [figs. 1–1d].
>
> The species should be named for Prof. Lester F. Ward, who has done so much for American paleobotany and has ever encouraged the writer in his studies.

[a] Paleontology of the Cretaceous formations of Texas. The invertebrate paleontology of the Trinity division, by Robert T. Hill: Proc. Biol. Soc. Wash., Vol. VIII, 1893, pp. 9–40, pl. i–viii.

The form occurs from Glenrose southward to the Colorado in great quantities and ranges throughout the Colorado River section.

It could be doubtfully referred to the genus Araucarites, which it more closely resembles than any other, although this is for the botanists to determine.

On pl. i, figs. 1, 1a–d, he figures one of the globular objects and a series of markings designated imbricate scales of cone, seeds, scars, etc.

The same year Prof. F. W. Cragin published in the Fourth Annual Report of the Geological Survey of Texas[a] a description of this same form, making it a new genus of Bryozoa, which he names Porocystis, and describes on p. 165, giving to the Texan form the specific name *pruniformis*. It is figured on pl. xxiv, figs. 2–6. In the discussion he refers to Mr. Hill's paper on the Occurrence of Goniolina, and says that "specimens submitted to the late Dr. Ferdinand Roemer, and which, like most of those that have thus far been collected, were imperfect and deceptive in surface-characters, were returned marked, '?Parkeria sp. nov.'" He also speaks of having "discovered the polyzoan nature of this so-called Goniolina."

Two years later a German paleontologist, Hermann Rauff, having received from Professor von Koenen five specimens of the fossil organism, collected at Bull Creek Bluffs, on the Colorado River 6 miles west of Austin, Tex., made them the subject of a very thorough investigation, the results of which he published.[b] This is by far the most exhaustive study that has been made of this organism. His figures are very clear, and he magnified portions of the surface ten diameters, showing the exact nature of the peculiar pits with which it is covered. He finds these to consist of polygonal (hexagonal, pentagonal, etc., very irregular and unequal sided) areas separated by raised lines and crossed by straight, depressed lines or cracks that divide them into four quadrants. Within each of these little frames, but rarely in the center, there is a minute boss or button nearly circular in section, and rising as high as the walls or higher. By radial sections he was able to prove that these latter represent the summits of little tubes, now filled with mineral substances. These tubes penetrate the sphere, but could not be traced far. They appear, however, not to go to the center, but to take an oblique direction

[a] Contribution to the invertebrate paleontology of the Texas Cretaceous, by F. W. Cragin: Fourth Ann. Rep. Geol. Surv. Texas, Austin, June, 1893, pp. 139–246, pl. xxiv–xlvi.

[b] Ueber Porocystis pruniformis Cragin (=? Araucarites Wardi Hill) aus der unteren Kreide in Texas, von Hermann Rauff: N. Jahrb. f. Min., etc., 1895, Bd. I, pp. 1–15, pl. i.

toward one of the poles. At what may be regarded as the proximal pole or stem end they lie on the surface, producing a fluted appearance in the polar depression or concavity.

Rauff leaves the problem of its true nature unsolved and proposes no new name, but he regards Mr. Hill's reference of it to Araucarites or to any conifer as probably erroneous. He does not deny its possible polyzoan nature, but finds analogies with the protozoan forms Receptaculites and Isohadites, which he had been studying. These possess organs somewhat similar to those that occupied the tubes of Porocystis, and which he calls *radials* (rootlets). He admits the possibility of these objects representing calcareous algæ. The specimens studied by Rauff are in the museum of the University of Göttingen.

I know of no study of this organism later than that of Rauff, but a thorough search into the literature has brought to light a memoir in which it was treated much earlier than any of the papers here noticed, viz, in 1853. Roemer does not mention it in any of his early works on the paleontology of Texas, and seems not to have met with it, but a man named Meusebach, who was probably one of the New Braunfels colonists, collected fossils in that region and early sent specimens to the Mineralogical Museum at Halle. Upon this collection C. G. Giebel published a report,[a] saying that it had long been in the museum. On page 375 he describes *Siphonia globularis* n. sp., and figures it on plate vii, figs. 3a, 3b. The description and figures give no reason to doubt that they relate to the organism in question. His fig. 3a is a view of one of the poles and shows the radiating tubes, while fig. 3b is a side view; and although these figures are not clear like those of Rauff, and not magnified, they fairly represent the average condition of these objects. He describes them as "spherical bodies from a few lines to an inch in diameter, with a somewhat depressed apex (*Scheitel*), the center of which is sunk to the depth of 2–4 lines into a large circular basin. From this radiate irregular, close-pressed furrows, scarcely reaching the margin, and passing into regularly arranged, thickly crowded, round pores, which are separated by spaces about equal to their diameters, though in the largest specimens they are smaller than their interspaces." He had before him 24 specimens, which he says strikingly

[a] Beitrag zur Paläontologie des Texanischen Kreidebirges, von C. G. Giebel: Jahresbericht des naturw. Vereines in Halle, Fünfter Jahrgang, 1852, Berlin, 1853, pp. 358–375, pl. vi, vii.

resemble *Siphonia excavata* and *S. præmorsa* of Goldfuss. The markings of the surface, however, differed so much from these that he seemed obliged to give them a different specific name. Giebel says that most of the specimens sent by Meusebach were labeled as coming from "Cibolo, 8 miles from Comanche Springs," but some were from Henderson, between New Braunfels and Guadelupe, while still others were simply labeled "Texas," and he does not state how the Siphonia specimens were labeled. As, however, the beds holding these organisms are widely distributed throughout that general region, this defect in the record is immaterial.

Amid all this variety of opinion and confusion in trying to classify this form, it is, of course, impossible to decide the question even to which of the two great kingdoms of nature, vegetable or animal, it really belongs, and we must be content for the present to leave it as wholly problematical. It is quite certain that it is not coniferous or a plant of any of the high types of structure, and if a plant at all, it must belong near the line at which the two kingdoms blend. I collected over 50 specimens, besides parts of the vine-like stems that seem to bear them, and at some future time I hope some competent investigator, in the light of what has thus far been done, will subject them to a more searching analysis and wider comparison with the living and fossil organisms that they resemble, and will thus discover and make known their true nature.

The name must also remain doubtful, at least the generic name, but Giebel's paper seems to be the earliest of all, and therefore the specific name that he gave it must stand, whatever the genus may be. If he is right and it is a Siphonia, this leaves it as he placed it. If found to belong to any other established genus, Giebel's specific name must be connected with that genus name. If it is a new genus, whatever its affinities, Cragin's genus Porocystis must be used.

Returning to the itinerary, I need only add that after Mr. Hill left the party at Bluffdale, on October 14, I continued the reconnaissance over the Trinity beds, following up the Paluxy to Morgans Mills and some 8 miles farther in a northwesterly direction, to where they were seen to rest on the brown Carboniferous sandstones holding encrinites and spirifers, thence to Wolf Creek, where fine exposures occur, some of which hold poorly preserved vegetable remains, and then to Woodrock Hollow, a dry canyon on the right bank of the Paluxy, 2 miles below Bluffdale. Along

the greater part of the length of this canyon and its several branches, as well as farther up on its sides, there are vast quantities of silicified wood, some of it in good condition. Well down in the ravine are some high bluffs giving fine exposures of Trinity sands with clay seams. In one of these there is a dark layer containing obscure vegetable remains, among which a cycadaceous leaf could be made out. From some of these cliffs vertebrate bones may be seen projecting. They were much decayed, but a good collection could probably be made by excavation in the soft sands.

After further examination of the beds in the valley of the Paluxy, I crossed the divide to the Bosque, which also traverses Trinity strata, the Glen Rose beds capping the hills. This valley was examined from Stephensville to Hico, and I returned from the latter place to Granbury by way of Glenrose, having seen all the principal phases of the Trinity formation, and collected such specimens of vegetable nature as they yield.

Mr. Harvey made a good collection of the plants from the Glen Rose beds in the Paluxy Valley and shipped them in eight boxes to Washington, where they arrived on January 22, 1892. As it was desirable to have a report upon them as early as possible, they were sent to Professor Fontaine at once for determination. In preliminary reports dated January 30 and March 10, 1892, he was able to correlate the flora in its leading aspects with that of the James River beds of the Older Potomac. His final report was rendered in August and was published in the Proceedings of the United States National Museum.[a] The flora as thus made known consisted of 23 distinct forms, 7 of which occur in the Potomac formation, 4 in the Wealden, and 2 in the Urgonian. The 10 new species and varieties were near to species from these formations, especially the Potomac. No dicotyledons were found in the Trinity.

The collections that I made in the Trinity of Arkansas were not sent to Professor Fontaine at the same time as those from the Glen Rose beds of Texas, but on October 28 they were sent him along with a number of other small collections. In a letter from him dated January 23, 1894, he says of these plants:

> The specimens that you sent me from near Murfreesboro, Ark., make it certain that the plants of the Glenrose, Tex., region which belong to the lower nonmarine

[a] Notes on some fossil plants from the Trinity division of the Comanche series of Texas, by William Morris Fontaine: Proc. U. S. Nat. Mus., Vol. XVI, 1893, pp. 261–282, pl. xxxvi–xliii.

member occur there also. The plant, *Frenelopsis varians*, found in both the Arkansas and the Texas beds, is a peculiar one, and is so strongly characterized that it can not be mistaken.

Dr. Johannes Felix collected from Neocomian strata of Tlaxiaco, Mexico, certain apparently jointed stems closely resembling those found in the Trinity and Glen Rose beds, which were described and figured in 1893 by Dr. A. G. Nathorst,[a] who considered them a new genus which he named Pseudofrenelopsis, the species being named *P. Felixi*. Nathorst, however, had not seen Professor Fontaine's paper on the Glen Rose flora, which appeared about the same time as the work of Felix and Lenk, but he regarded the form as generically the same as the *Frenelopsis parceramosa* of Fontaine from the Potomac formation. A comparison of his figures, however, indicates that the Mexican plant is different from either the Virginia or the Texas-Arkansas form, and the last named is certainly jointed, and therefore, according to Nathorst, a true Frenelopsis.

I have not included the Tlaxiaco flora in this paper, although belonging to the Lower Cretaceous of North America; I will therefore add that besides the *Pseudofrenelopsis Felixi*, Nathorst describes coniferous twigs which he compares with *Sequoia ambigua* Heer and *S. Reichenbachi* (Gein.) Heer.

The Trinity beds of Arkansas have yielded one other vegetable form that has not yet been mentioned, because, although collected by Mr. Hill in 1888, it was not described till 1895. The material in which it occurs was placed in Doctor Knowlton's hands, and this form is mentioned in a letter from the latter to Mr. Hill, which was appended as a footnote to the chapter on the paleontology of the Trinity division (Chap. XIII, p. 152) of the Annual Report of the Geological Survey of Arkansas, Vol. II, in which Doctor Knowlton says:

> There was a very interesting thing in some of the clayey material. It was thickly filled with stems, as you may remember. I selected a few of them, boiled them out in nitric acid, and mounted them in Canada balsam, when the structure was brought out most clearly. It is something new, evidently, and so far as I could find in the time I was able to give the subject, is undescribed. I have not decided what to call it, and indeed a mere description, without accompanying plates, would be of very little scientific value.

[a] Pflanzenreste aus dem Neocom von Tlaxiaco, by A. G. Nathorst in Beiträge zur Geologie und Paläontologie der Republik Mexico, von J. Felix und H. Lenk, II. Theil, Leipzig, 1893, pp. 51–54. See p. 52, figs. 6–9.

In his paper describing this organism Doctor Knowlton says that the specimens in which it occurs "came from a gulch on one of the smaller branches of the Muddy Fork of Little River, about 6 miles northeast of Centerpoint, Howard County. The deposits containing these fossils were referred by Professor Hill to the Trinity division of the Lower Cretaceous." He was unable to fix its systematic position, and treated it as a new genus, which he named for Mr. Hill and called the form *Paleohillia arkansana.*[a] Mr. Theo. Holm published a criticism of Doctor Knowlton's conclusions relative to this form,[b] but as he did not himself see the specimens his conclusions are entitled to little weight.

I have now enumerated all the vegetable remains (with the exception of "an undescribed endogenous plant resembling Equisetum"[c] from the Arietina beds of the Washita division) that have thus far been reported as having been found in the Comanche series of Texas and Arkansas, and have given a somewhat full account of the history of the discovery of fossil plants in the Trinity formation. Although the flora has thus far proved meager, it is sufficient to show, even if the fauna and the stratigraphy failed to do so, that the Trinity formation is of Lower Cretaceous age. The absence of dicotyledons, however, seems to place it at the very base and give it homotactic rank with the Knoxville and the Kootanie.

The Twenty-first Annual Report of the United States Geological Survey, Part VII,[d] which bears date 1901, but really did not see the light until May, 1902, constitutes Mr. Hill's final contribution to the geology of Texas, and would seem to exhaust the subject. The Black and Grand prairies occupy most or all of the Cretaceous terranes within the State, although they are not confined to them, and their description afforded Mr. Hill an opportunity to deal at length with the beds that have chiefly occupied us thus far. He has, however, made scarcely any change in the classification of the rocks, and adheres to the conclusions last announced.

[a] Description of a new problematical plant from the Lower Cretaceous of Arkansas, by F. H. Knowlton: Bull. Torr. Bot. Club, Vol. XXII, September, 1895, pp. 387–390, figs. 1–3 on p. 388.

[b] Remarks upon Paleohillia, a problematic fossil plant, by Theo. Holm: Botanical Gazette, Vol. XXI, April, 1896, pp. 207–209, pl. xvii.

[c] Bull. Geol. Soc. Am., Vol. V March 22, 1894, p. 322, in Geology of parts of Texas, Indian Territory, and Arkansas adjacent to Red River, by Robert T. Hill: Ibid., pp. 297–338, pl. xii, xiii.

[d] Geography and Geology of the Black and Grand Prairies, Texas, with Detailed Descriptions of the Cretaceous Formations and Special Reference to Artesian Waters. By Robert T. Hill, Washington, 1901, 666 pp., 71 pls. (6 of which are maps), 80 text figs.

Neither does he seem to have found any additional material of a vegetable nature, and contents himself with enumerating the species described by Professor Fontaine (pp. 165–166) and reproducing his figures of the most striking of these (pl. xxvi). It therefore only remains to embody this work in the literature of our subject, and to draw attention to it as by far the most complete account thus far given of the geology of Texas.

FLORA OF THE OLDER POTOMAC FORMATION.

I shall use the term Older Potomac in this paper in the same sense as that in which it was used in my earlier paper on The Potomac Formation,[a] especially as given in the classification at the bottom of page 375, and in all the subsequent tables and discussions. This is in the main the Potomac formation as it occurs in Virginia, but also includes all beds of the same age occurring in other States. It excludes from the Potomac formation, as I have used the term, only those higher beds in which the flora is mainly dicotyledonous, which are also very extensive and have yielded a rich flora, and which, together with all other beds of practically the same age (Tuscaloosa, Cheyenne sandstone, etc.), will form the subject of the next or third paper of this series.

HISTORICAL REVIEW.

Although the object of this series of papers is primarily to treat the floras of the several formations considered, there is always a long period during which the geological and lithological relations chiefly attract attention, with only occasional reference to the more striking paleontological phenomena. These early groupings are of especial interest from the historical point of view, and an account of them is essential to a full understanding of the nature of the formation. This is practically true of the Older Potomac, and the account will be made as complete as the data will permit.

The earliest reference that I find to rocks of this age is contained in two papers by Mr. B. H. Latrobe, one of which dates back to the year 1799.[b] On page 442 of this paper he states in a footnote that the lighthouse at Cape Henry "is a good solid building of Rappahannoc freestone."

[a] Fifteenth Ann. Rep. U. S. Geol. Survey, 1895, pp. 307–397.

[b] Memoir on the sand-hills of Cape Henry in Virginia, by B. Henry Latrobe: Trans. Am. Phil. Soc., Vol. IV, Philadelphia, 1799, pp. 439–443.

This shows that the freestone quarries on and near the Rappahannock River had long been worked at that time. The other paper, published ten years later,[a] is devoted to "the freestone quarries on the Potomac and Rappahannoc, from the former of which the freestone employed in the public buildings of the United States at Washington is obtained" (p. 284). He gives a good description of the freestone rock, including that of the clay nodules so characteristic of it. On page 287 he says:

Wood, from trunks and branches of trees of large size to small twigs, either entirely carbonated or the wood carbonated and the bark in a fibrous state, so as to have the appearance of a net, and a considerable degree of tenacity; or the bark fibrous and the wood in a state quite friable; or the wood replaced by pyrites which effloresce in the air; or in *cavities* the sides of which have the impression of branches in minute ramification and are lined with a pellucid crust, probably calcareous spar. This latter evidence of the admixture of wood is to be found chiefly near Fredericksburg.

On July 15, 1823, Mr. John Finch read a paper before the Academy of Natural Sciences of Philadelphia[b] in which he classed all the beds of the coastal plain as Tertiary and compared them with those of Europe. On page 39 of this paper he says: "At Washington, under the mass of diluvian gravel of which the higher part of the Capitol hill is composed, there is a stratum of clay which contains many organic remains. Trunks and branches of trees are found at a distance of fifty-four feet from the surface." It is probable that these remains were in the Potomac formation, although they may have been in the overlying Columbia formation, in which such objects have been found within the city of Washington.

In 1829 Messrs. Morton and Vanuxem published a paper of a very general character,[c] but their "Secondary formation" evidently includes the whole of the Potomac formation and also the marls of New Jersey. In the following statement they exactly describe the conditions under which the wood and lignite of the Potomac formation occur:

In many of the States there is a bed of clay (No. 2 of the diagram) containing *lignite* or *charred wood*, with pyrites, amber, etc., which is no doubt represented in

[a] An account of the freestone quarries on the Potomac and Rappahannoc rivers, by B. H. Latrobe: Trans. Am. Phil. Soc., Vol. VI, Pt. II, 1809, pp. 283–293.

[b] Geological essay on the Tertiary formations in America, by John Finch: Am. Journ. Sci., original series, Vol. VII, 1824, pp. 31–43.

[c] Geological observations on the Secondary, Tertiary, and alluvial formations of the Atlantic coast of the United States of America, arranged from the notes of Lardner Vanuxem, by S. G. Morton, M. D.: Journ. Acad. Nat. Sci. Philadelphia, Vol. VI, Pt. I, 1829, pp. 59–71.

many places by beds of sand containing woody fiber replaced by siliceous matter, for in all cases where wood is enveloped by clay, which admits with difficulty the percolation of water, the mass is found in a black, charred state; but, on the contrary, when deposited in a matrix which admits the infiltration of water, such as sand, soil, or loam, the wood appears in the *replaced* or *petrified* state.

Dr. Edward Hitchcock, in his early report, published in 1833, had of course only to deal with the northern extension of the Potomac formation, which contains none of the older beds, but he was aware of the great extent of this formation, as evidenced by the following remark:

> The patches of this formation that have been described in Massachusetts are doubtless only the remnants of a vast extent of these strata, extending at least from Cape Cod to the borders of the Gulf of Mexico, and how far eastward, where the Atlantic now rolls, we can form no probable opinion, though there is some reason for supposing that they once even reached Europe, along whose shores similar strata are found at present.[a]

Messrs. Clemson and Taylor commenced their extended investigations into the geology and mineral resources of Virginia at about this time and published their first papers in 1835.[b] Mr. Clemson concludes his paper with a fairly full description of the Potomac beds in the vicinity of Fredericksburg, including that of "Alum Rock," a mile south of that place. He also refers to the lignites and fossil wood found in that region, and speaks of "a blue argillaceous bed six inches to a foot in thickness, which divides easily and displays to view fine impressions of plants" (pp. 312–313). This appears to be the earliest mention of plant impressions in the Older Potomac formation, and may allude to the same locality where Professors Uhler and Fontaine later obtained so large an amount of material of this class.

Mr. Taylor, in the paper[c] that immediately follows this, devotes six pages (320–325) and one folded plate (pl. xix) to the description and illustration of the plants from this locality. He states that his "attention was first directed to these plants by Mr. F. Shepherd, who at our request

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[a] Report on the Geology, Mineralogy, Botany, and Zoology of Massachusetts, by Edward Hitchcock, Amherst, 1833, pp. 201–202.

[b] Notice of a geological examination of the country between Fredericksburg and Winchester, in Virginia, including the gold region, by Thomas G. Clemson: Trans. Geol. Soc. Penna., Vol. I, Pt. II, Philadelphia, 1835, pp. 298–313, pl. xvii.

[c] Review of geological phenomena, and the deductions derivable therefrom, in two hundred and fifty miles of sections in parts of Virginia and Maryland; also notice of certain fossil acotyledonous plants in the Secondary strata of Fredericksburg, by Richard C. Taylor: Ibid., pp. 314–325, pls. xviii–xix.

furnished the Geological Society with specimens" (p. 321). The seven figures given on the plate are clear and show the true nature of the plants, but the nomenclature employed is of course antiquated. As will be seen on page 373, Professor Fontaine was able from the figures to determine most of the forms. Mr. Taylor saw that these beds had nothing to do with those of the Richmond coal field, and his remarks on their stratigraphical position are somewhat important:

> As relates, therefore, to the evidence which these fossil plants furnish as to the relative age of the formation wherein they are deposited, we are led to the conclusion that it is of secondary origin, perhaps coeval with the oolites. They have no resemblance to any of the plants of the Richmond coal field that have come to our knowledge, and decidedly bear the impress of a more modern character.
>
> In this view we are confirmed by the lignites and silicified wood in some of these beds, which indicate a geological age much less remote than the coal fields of the Alleghanies, for instance, and still further removed from that of Richmond.
>
> The large broken masses of silicified wood are unquestionably remains of vasculares or dicotyledonous plants or trees, no member of which series has yet been observed in our coal vegetation. They resemble in some respects the silicified wood of the Portland oolite of England, and like them exhibit no marks of perforation by the Teredo.
>
> The silicified fragments found by Mr. Nuttall near the James River are described as "penetrated with quartz of an opaque white color, destitute of the resinous fracture, and easily crumbling into an almost impalpable sand." The latter character prevails in the Fredericksburg lignites, and some of them are coated with small quartz crystals.
>
> Again we have other lignites which are broken up and abundantly intermixed with the grits, and even in the finer argillaceous seams, which fragments occur only in the form of burnt or charred wood, not bituminous, but having their ligneous fibers preserved.
>
> We have, moreover, a distinguishing evidence of the more recent character of these deposits than those of the Richmond coal field, in the friable open texture of the grits, which are no more crystalline than ordinary oolites, whereas the rocks of Richmond are compact, frequently subcrystalline and porphyritic.
>
> It must be observed that all the genera to which we have assigned the fossil plants of Fredericksburg occur in the oolitic group of Europe. For this fact we have the testimony of M. A. Brongniart, Saussure, Phillips, Murchison, De la Beche, and many others. These genera have also been found, according to M. Elie de Beaumont, to a certain degree associated with belemnites and other fossils of the lias, inasmuch as those fossils are embedded both above and beneath them. But we have seen no traces of algæ, cycadeæ, or of coniferæ, all of which orders occur sparingly in the oolitic series of Europe (pp. 324, 325).

The paper by Nuttall from which Mr. Taylor takes the above statement appeared in the Journal of the Academy of Natural Sciences of Philadelphia, Vol II, Pt. I, 1821, and the statement occurs on page 37. "On examining the context I am satisfied that the fossil wood described came from the Older Mesozoic and is of the same age as the Richmond coals and not of Potomac age."

In this same year (1835) was begun the important series of reports by Prof. W. B. Rogers, State geologist of Virginia, on the geology of that State. In the first of these, which was only a reconnaissance, he devotes a section to the "sandstones overlying the Primary rocks along their eastern boundary,"[a] in which he describes the Older Potomac beds in the vicinity of Fredericksburg and below Richmond and Petersburg, mentioning the Aquia Creek quarries. He says that "in the superior portion of these beds lignites, silicified wood, and vegetable impressions are frequently to be seen—all of which contribute to render the examination of these deposits a subject of much curious interest to science."

Professor Rogers did not again discuss the beds of this age until 1840. In his report for 1839[b] he characterizes it as the "Sandstone formation" (p. 20), and traces it as far south as Bollings Bridge on the Nottaway River (p. 17). In his next report[c] he devotes most of Chapter III to this formation, which he first describes as "The narrow belt extending along the eastern margin of the primary from Petersburg to the Potomac River (p. 26), and afterwards designates the "Upper Secondary" (p. 29). He devotes a section (Sec. II) to bounding the formation and another (Sec. III) to describing its characters and contents. He sometimes speaks of the freestone as "loose-grained feldspathic sandstone" and accurately describes its mineralogical character, but does not make use of the term "arkose." On page 36 he takes some pains to show that these beds are not the same as, and are younger than, the coal basins of Henrico, Chesterfield, etc., counties, now known as the Richmond coal field, but

[a] Report of the Geological Reconnaissance of the State of Virginia, made under the appointment of the board of public works, by William B. Rogers, Philadelphia, 1836, p. 61.

It should be stated that this and all the subsequent reports of Professor Rogers are literally reprinted in a much more accessible form in the volume entitled, A Reprint of Annual Reports and other Papers, on the Geology of the Virginias, by the late William Barton Rogers, New York, 1884.

[b] Report of the Progress of the Geological Survey of the State of Virginia for the year 1839, by William B. Rogers, Richmond, 1840.

[c] Ibid., 1840, Richmond, 1841.

the description occupying the remainder of the section clearly relates to the Potomac beds.

In his paper "On the Age of the Coal Rocks of Eastern Virginia,"[a] devoted chiefly to the older of these formations, he refers to the younger beds as follows:

> The coarser rocks, lying above the carbonaceous strata, and forming the greater part of the thickness of the series, contain very few organic remains, and those in so imperfect a condition as to have little or no value for purposes of comparison. There are, however, strong reasons for believing that these strata, by a gradual transition, pass upward into the series of felspathic sandstones, described in my report of the Geological Survey of Virginia for 1840, under the title of *Upper Secondary Strata*. The latter, considered by Messrs. Taylor and Clemson, as "of secondary origin, perhaps coeval with the Oolites," have since been referred by myself and Prof. H. D. Rogers to the *upper part* of the Oolite series, so that this great division of the geological column, though still perhaps very imperfectly represented in the United States, comprises a thickness of considerably more than one thousand feet of strata (see p. 301).

Mr. Richard C. Taylor, in his work on the Statistics of Coal, published in 1848, returns to this subject[b] in the treatment of the coals of Virginia. Relative to the lignites, silicified wood, and fossil plants he says:

> In 1834 the Geological Society of Pennsylvania published in their first volume a paper communicated by the author of this work on the lignites of the secondary horizontal strata of Fredericksburg, accompanied by six lithographed figures of plants. These lignites are in no place in sufficient abundance to constitute a seam or bed, much less a workable bed, but as interesting specimens of silicified masses of wood and fragments even of large trees, which reminded us of those of the Portland rock of the south of England; besides an infinite number of impressions and carbonized remains of more delicate varieties of plants, that are not undeserving of a passing notice.
>
> On looking over the imperfectly defined series of these plants, it will be seen that they are all cryptogamous, cellulares, or acotyledones, with the exception of Thuytes, and that they belong to genera some of whose species are distributed abundantly amongst the coal vegetation of all parts of the world. These species, however, appear to be new—that is, they do not belong to the Carboniferous period. One approaches to the Oolite period, and the consideration given to this group of plants led to the conclusion that they were "perhaps coeval with the Oolites."

[a] Trans. Assoc. Am. Geol. and Nat., Boston meeting, 1842, Philadelphia, 1843, pp. 298–301.

[b] Page 54. Second edition, revised and brought down to 1854 by S. S. Haldeman, Philadelphia, 1855, p. 299.

The large, broken masses of silicified wood are, unquestionably, remains of vasculares or dicotyledonous plants or trees, no member of which, we believe, has yet been observed in our ancient coal vegetation. These resemble, somewhat, the silicified wood of the Portland Oolite, and like them, exhibit no marks of perforation by the teredo.

It must be observed that all the genera to which we assigned the fossil plants of Fredericksburg occur in the Oolitic group of Europe. For this fact we have the testimony of M. A. Brongniart, of Saussure, Phillips, Murchison, De la Beche, and many others.

It is undoubtedly to what is now known as the Potomac formation, but not wholly to the Older Potomac, that the following description of Messrs. Meek and Hayden, made on May 26, 1857, refers:

There is at the base of the Cretaceous system, at distantly separated localities in Nebraska, Kansas, Texas, New Mexico, Alabama, and New Jersey, if not, indeed, everywhere in North America where that system is well developed (at any rate east of the Rocky Mountains) a series of various colored clays and sandstones and beds of sand often of great thickness in which organic remains, excepting leaves of apparently dicotyledonous plants, fossil wood, and obscure casts of shells, are very rarely found, but which everywhere preserves a uniformity of lithological and other characters, pointing unmistakably to a similarity of physical conditions during their deposition, over immense areas.[a]

Mr. Philip T. Tyson commenced his official operations as State agricultural chemist of Maryland in May, 1858. He recognized the necessity of a geological survey of the State and devoted two seasons exclusively to field work. The map accompanying his first report[b] shows how far he was successful in working out the general geology of Maryland. He enumerates twenty-four formations, of which the "Cretaceous group or chalk period" includes Nos. 21 and 22 in an ascending scale, and thus describes them:

1. A thick group of sands and clays of various colors, but principally white, red, and bluish gray, with some thin beds of ferruginous sandstone resting immediately upon No. 5. In some localities it abounds in lignite derived from coniferous plants. The bluish-gray varieties derive their color from the carbonaceous remains of plants; but we have not yet met with fragments of sufficient size for determination.

[a] Descriptions of new species and genera of fossils, collected by Dr. F. V. Hayden in Nebraska Territory, under the direction of Lieut. G. K. Warren, U. S. topographical engineer; with some remarks on the Tertiary and Cretaceous formations of the north-west, and the parallellism of the latter with those of other portions of the United States and Territories, by F. B. Meek and F. V. Hayden: Proc. Acad. Nat. Sci. Philadelphia, 1857, Vol. IX, 1858, pp. 117–148 (see p. 133).

[b] First Report of Philip T. Tyson, State Agricultural Chemist, to the House of Delegates of Maryland, January, 1860

2. Iron-ore clays (No. 22 in the illustrations). This subdivision consists of a series of beds of fine gray and lead-colored clays containing several courses of carbonate of iron in flattened masses and nodules, varying in size from a pound or two to half a ton or more in weight. The color of these clays is due to carbonaceous matter (pp. 41, 42).

He very early found a portion of a tooth of a saurian reptile in an iron-ore bed near Bladensburg. This he sent to Dr. Christopher Johnston, who regarded it as indicating a new genus and named this genus Astrodon.[a] This tooth was more fully described later by Prof. Joseph Leidy and the species named for Doctor Johnston, *Astrodon Johnstoni*.[b] It is barely referred to in Mr. Tyson's report on page 42 as coming from his No. 22, which is the older bed and includes the iron-ore clays. From this bed were also obtained the only plant remains, consisting of "a new genus of Cycas of large dimensions," "silicified coniferous wood," and "lignites (coniferous)."

In his second report, published in 1862, Mr. Tyson discusses these iron ores in Chapter VI, and on page 54 says:

> On page 42 of the first report I took occasion to refer briefly to what I called *iron-ore clays*, numbered 22 in the table of formations. At that period it was believed that this formation should be placed with the formations of the *Cretaceous period* in geology. Since then, however, I am disposed to place it at least as low as the oolitic period. M. Agassiz, to whom I exhibited a photograph of the fossil Cycas (noticed in the first report, and of which I have discovered several specimens in this formation), fully agrees with me in this regard.
>
> These clays possess an especial interest to us from the existence therein of large deposits of iron ores, from which it is believed the first pig iron was made in this State. The quality of the metal is very superior.
>
> This ore, which is known as *carbonate of iron*, has a local name of *hone ore*, from its resembling a hone in its texture and color. It usually contains from 32 to 40 per cent of iron. It exists in flattened nodules, varying in size from the weight of a few pounds to one hundred or more, which are embedded in the iron-ore clays of formation No. 22.
>
> These clays range nearly parallel with the lines of railroad from Washington, via Baltimore and Havre de Grace, nearly to Elkton, and do not extend either into Virginia or into Delaware. They constitute a formation peculiar to Maryland.

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[a] Am. Journ. Dental Science, New Series, Vol. IX, Philadelphia, July, 1859, p. 341.

[b] Smithsonian Contributions to Knowledge, No. 192, Vol. XIV, Article VI, 1865, p. 102, pl. xiii, figs. 20–23; pl. xx, fig. 10.

He found a considerable number of these cycadean trunks and sent some to geologists in different parts of the country. He had photographs made of some of the finest specimens and distributed the prints far and wide, seeking to obtain the opinion of all as to their true nature. The specimen sent to Sir William Dawson will be mentioned later on (see p. 409). One seems to have found its way to South Carolina College, Columbia, S. C., an account of which will also be given (see p. 411). Some of the photographs have also come into my hands and will be considered at the proper time (pp. 409–410), as also the fine series that remained in the Maryland Academy of Sciences and were ultimately turned over to the Johns Hopkins University, where they still are. These fossils are mentioned in the first edition of Dana's Geology, 1863, page 472, as follows: "Large stumps of Cycads have been found in Maryland near Baltimore; one is 12 inches in diameter and 15 high. (P. T. Tyson observes that they may be Upper Jurassic)." This reference is mentioned by Carruthers in his principal memoir on cycadean trunks,[a] and he states in a "postscript" to the memoir that Dawson had shown him a photograph of one of Tyson's specimens, and adds:

> The specimen from which it was taken was fifteen inches in height. It is obviously a species of Bennettites, with smaller leaf-scars than those in *B. Saxbyanus*. Numerous axillary branches are seen, some of which are hollow in the center from the fruits having perished. Doctor Dawson informs me that Mr. Tyson regards the beds in which he obtained the specimens as most probably of Wealden age. [See p. 409.]

The short paper read by Prof. E. D. Cope before the Academy of Sciences of Philadelphia on June 2, 1868,[b] although chiefly relating to the beds that I class as "Newer Potomac," evinces such a comprehensive grasp of the general geological relations of the then little-known Lower Cretaceous brackish or fresh-water beds of the Atlantic slope that it is refreshing reading even to-day, and I reproduce here those parts of it that have a general bearing on the history of our knowledge of the Older Potomac:

> These deposits belong to Meek and Hayden's Earlier Cretaceous, No. 1, which contains abundant remains of leaves on the Raritan River, but no animal fossils.

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[a] On fossil cycadean stems from the Secondary rocks of Britain, by Wm. Carruthers: Trans. Linn. Soc., Vol. XXVI, 1870, pp. 675–708, pl. liv–lxiii (see p. 679).

[b] Proceedings, Vol. XX, 1868, pp. 157–158.

Their age has been hitherto quite uncertain; they have been stated by Meek and Hayden to be the earlier division of the later Cretaceous of the general geologic series. They extend across the States of Delaware, Maryland, and Virginia. In Maryland they are stated by Ducatel to contain the important deposits of carbonate of iron; and Philip Tyson, State geologist, informs me that these beds lie upon the red and blue clays, forming hills, which have been produced by erosion of the valleys to the beds below. These iron clays contain several species of cycadaceous plants, whence Tyson infers the age of the clays to be Jurassic and not Cretaceous.

There are in the museum of the Smithsonian Institution, Washington, several specimens of fossil Unios, from a ferruginous clay which crops out at some elevation on the banks of the Potomac. These species are identical with those which have been found in the New Jersey clays, and the deposit is doubtless the same as that which traverses the State of Maryland.

Indurated grey clays on the Rappahannock River have been examined by my friend Philip R. Uhler, of Baltimore, who has obtained from them leaves and stems of some six species of plants, in beautiful preservation, of the orders Cycadaceæ,? Gnetaceæ and Filices. The position and character of this bed render it excedingly probable that it is a continuation of those of Maryland and Alexandria.

The whole formation indicates the existence of an extended body of fresh water, having a direction and outline similar to that in which were deposited the red sandstones and shales of the Triassic belt, which extends parallel to its northwest margin throughout the States in which it occurs, separated, except in New Jersey, by a broad band of gneiss and Potsdam rocks. The carbonate of iron was no doubt deposited in a bog or bogs along its margin or in its shallows, as the bottom became elevated, as suggested by Tyson, though not in a salt-water swamp, as supposed by him. The Cycads and dicotyledonous trees grew in the swamps and on the shores, while terrestrial reptiles of large size no doubt haunted their shades.

These beds appear to dip conformably beneath the Lower Cretaceous marine beds in New Jersey, in which, at a distance of a few miles from their border, occurred the remains of the Hadrosaurus; and it is therefore not probable that they were cotemporary with these, as is the case with the Wealden of Kent and the Cretaceous at Maidstone, England. The Hadrosaurus clays, belonging to the Upper Cretaceous, as indicated by the presence of many molluscs of the Ripley group of Mississippi, appear to be separated from the clays in question by a great lapse of time. The age is therefore probably truly Wealden or Neocomian.

These facts indicate the existence of a barrier to the eastward of their present position, which for a long period prevented the access of salt water. This barrier was no doubt an anticlinal of the Appalachian series, outside of that which walled in the Triassic fresh-water area, and, like it, parallel with the general series of anticlinals of the present Allegheny range. That it was, like the latter, at one time submarine, and, gradually rising, finally enclosed the area in question, the waters of which soon became fresh, from the numerous rivers which flowed into it.

On the gradual elevation of this fresh-water valley, with its included beds of clays, etc., the Delaware River cut its way through the latter nearly to the southeastern rise, and was then deflected along the base of these first elevations of the bounding anticlinal, in a southwest direction. Thus is accounted for the apparently singular phenomenon of the great bend of the Delaware River near Bordentown. For after penetrating the high ranges of the Blue Mountains, it remains to be turned, apparently, in a level country of sands and clays.

We must suppose the coast line to have been not far from the southeastern base of this anticlinal, and that a subsequent submergence brought the marine deposits near to the margin of the fresh, and gave the latter the southeast dip visible at the section of the Pea shore. I have not yet been able to ascertain the relative position of the margins of these beds, nor the nature of those that conceal the supposed anticlinal. A system of borings at a distance of two or three miles from and parallel to the Delaware would do much toward explaining this point. It is to be hoped that this may be undertaken by the present State Survey, under Professor Cook.

At the present time the cities of Alexandria, Washington, and Baltimore stand upon its deposits, and Philadelphia is probably underlain by its margin, as well as the adjoining margin of the gneiss. Indeed, the location of the prominent cities of the Atlantic States appears to have been determined by the fine sites and water-powers offered by the junction of the high rolling country of the gneiss formation, and the lower and more level regions of the supposed Neocomian, Cretaceous, and Tertiary. Where the gneiss strikes the ocean is situated our greatest seaport, New York. Trenton, Philadelphia, Wilmington Baltimore, Washington, Alexandria, Richmond, Raleigh, Columbia; and Milledgeville, Georgia, are all on this line of juncture. The elevated gneiss hills furnish healthy and beautiful residences, the fall furnishes water power, and the lower level, water communication, and a light soil most suitable for gardening and the production of provisions for these centers of population.

At the meeting of the Boston Society of Natural History of May 19, 1875, Prof. W. B. Rogers presented some "Geological Notes," one of which was "On the Gravel and Cobblestone Deposits of Virginia and the Middle States,"[a] which is remarkable from the fact that Professor Rogers here clearly distinguishes the more superficial gravels belonging to the Pleistocene beds, now called the Columbia formation, and the Pliocene beds, known to modern geologists as the Lafayette formation, from the Cretaceous gravels belonging to the Older Potomac. Toward the close of the paper he enters somewhat into the general discussion of

[a] Proc. Boston Soc. Nat. Hist., Vol. XVIII, May 19, 1875, pp. 101–106; Geology of the Virginias, pp. 707–713.

the relations of these beds in the States of Virginia, Maryland, Delaware, and New Jersey, and although it was not then known that the more northeasterly outcrops represent a higher phase of the formation, with an entirely different flora, the views here expressed represent the common opinion prior to the investigations of Professor Fontaine, Doctor Newberry, and myself of the floras yielded by these beds. He says:

In the belt partially occupied by the surface deposit here referred to there is exposed another group of strata with which, at first view, the sandy and argillaceous layers of this formation might readily be confounded. These are the silicious, argillaceous, and pebbly beds, which, underlying the Tertiary in Virginia, and the well-marked Cretaceous formation farther north, have, in the latter region, been regarded as belonging to the base of the Cretaceous series of the Altantic States. In Virginia the formation consists typically of a rather coarse and sometimes pebbly sandstone, in which the grains of quartz and feldspar are feebly cemented by kaolin, derived from the decomposition of the latter, and of argillaceous and silicious clays variously colored and more or less charged with vegetable remains, either silicified or in the condition of lignite. These constitute the group of beds designated in the Virginia geological reports as the Upper Secondary Sandstone, and referred by me long since (1842) to the upper part of the Jurassic series, corresponding probably to the Purbeck beds of British geologists. From the Potomac northward this group of deposits, as exposed in the deep railroad cuts between Washington and Baltimore and on to Wilmington, is made up of variegated, soft, argillaceous, and silicious beds, which, from the preponderance of ferruginous coloring toward the Delaware, has been called by Professor Booth the red clay formation. At a few points only toward the bottom of the deposit it brings to view a bed of the felspathic sand, or crumbling sandstone, above referred to. Traced transversely, it is seen to dip beneath the Cretaceous greensand at various points in New Jersey, Delaware, and Maryland, but in Virginia disappears in its eastward dip beneath the Eocene Tertiary.

How far we may consider this group of sediments in Maryland, Delaware, and New Jersey as merely a continuation of the Virginia formation above described can be determined only by further investigation. But the discovery in them at Baltimore, by Professor Tyson, of stumps of cycads would seem to bring them into near relation with the formation at Fredericksburg containing similar remains, and to favor their being referred, at least in part, to the horizon of the upper Jurassic rocks. Possibly we may find here a passage group analogous to the Wealden of British geology. Whatever may be the result of further discovery, it would seem to be premature at this time to assume the whole of these deposits from the Potomac northward as belonging to the Cretaceous series.

Where the Tertiary or Cretaceous rocks are present in this belt there is, of course, no danger of confounding the superficial gravel and cobblestone deposit with

the formation just described, but in their absence, which is usual in the river valleys, this deposit rests immediately on the broken and denuded surface of the Secondary, and by the intermixture of materials makes it more difficult to discriminate between them.

Excellent opportunities for observing the contact of the superficial deposit with the denuded and much older formation below are presented in the neighborhood of Washington, among which may be specially mentioned the vertical cut at the extremity of Sixteenth street, at the base of the hill occupied by Columbian College, and also the continuation of Fourteenth street, ascending the same hill. At the former locality the crumbling felspathic sandstone, or slightly adhering sand, is exposed to a height of about 35 feet, with a very gentle eastern dip, and having the color, composition, and diagonal bedding characteristic of the Fredericksburg and Aquia Creek sandstone. The gravel and cobblestone deposit lying upon it descends with the slope of the hill to the general plain below, resting at a somewhat steep angle against the denuded edges of the underlying beds. From this and other localities it becomes obvious that the latter formation has been deeply and extensively denuded before and during the deposition of the surface strata, which form the chief subject of this communication. (See pp. 104–105.)

Professor Fontaine must have commenced his investigations in the Mesozoic of Virginia at about this time, for in his first important series of papers[a] on the subject he says:

In this paper I present a summary of the results attained by a series of examinations made in the Mesozoic strata of Virginia. These examinations have occupied the larger portion of my summer vacations for several years. (See p. 25.)

In this paper he deals with both the Older and the Younger Mesozoic. In the first paper of this series[b] brief mention is made of the discussion of the former of these beds and its relation to the author's monograph on the flora of that epoch, which appeared four years later. It bore a similar relation to his Younger Mesozoic Flora, except that his materials were not yet so fully in hand, and much was done by him before that work was begun. But the general relations of these two epochs to each other were set forth in this paper and the differences not only in their geographical position but also in their lithological character were clearly pointed out. Considerable was also said of the flora. He divided the beds into two "b ts," the "Fredericksburg belt" and the "Petersburg belt," the former corresponding stratigraphically as well as geographically

[a] Notes on the Mesozoic of Virginia, by Wm. M. Fontaine: Am. Journ. Sci., 3d ser., Vol. XVII, January, 1879, pp. 25–39; February, 1879, pp. 151–157; March, 1879, pp. 229–239. Reprint, pp. 25–55.

[b] Twentieth Ann. Rep. U. S. Geol. Surv., Pt. II, 1900, p. 260.

with what he afterwards called the Fredericksburg beds, and the latter with the James River beds. To the whole he gave the name of the "Border belt." He recognized an "upper series," which included not only what he afterwards called the "Brooke" beds, but also most of the formation as it exists in Maryland. As this has an important bearing upon the Potomac of Maryland as now understood, it will be well to bring it especially to the reader's attention:

> The lower series passes up into a higher system of beds, constituting the upper series, which is marked by a smaller proportion of the white incoherent beds, so characteristic of the lower, and by a predominance of clays of reddish, yellowish, and bluish colors, and of reddish and yellowish sands. These clays and sands increase in amount as we follow the belt northward. Near Alexandria, between Washington and Baltimore, and near the latter city, they constitute the whole of the upper series. The material of these beds comes from the decay of the Azoic on the west. These clays and sands also are very irregularly bedded. The sands especially, are much affected by cross bedding. From Alexandria northward the lower series is rarely seen, being too deeply buried. At Baltimore it appears in the lowest white clays and sands dug in the base of the hills (see pp. 154–155; Reprint, p. 42.)

This paper contains the first mention of the "archaic dicotyledons" of the Potomac formation, the discovery of which has thrown so great light upon the origin of that subclass of plants and has caused such an extensive readjustment in the geological classification of plants. On this subject he says:

> With the plants above named, I find certain netted veined leaves, which by their nervation can not be distinguished from Angiosperms. Had they been found with Cretaceous or Tertiary plants I think no one would hesitate to consider them as such. As, however, they occur with a well-marked upper Jurassic flora, I hesitate to pronounce them to be Angiospermous plants without a more careful study and extended comparison than I have as yet been able to make. They are certainly not "Dictyophyllum" which is the genus of fossil ferns that stands nearest to them. But when we find such a development of undoubted Angiosperms in the lowest Cretaceous beds of New Jersey and of the west, we should expect to find at least their ancestors in the Jurassic flora (see p. 156; Reprint, p. 44.)

In speaking further of the Maryland beds he says:

> Great quantities of lignite occur in the clays of the upper series, especially the clays which Mr. Tyson calls "iron-ore clays," which are found between Washington and Baltimore. In these clays, stumps of Cycads, belonging to at least two new species of the genus Cycadoidea, are found. The blue clays at Baltimore yield some

beautiful ferns of Wealden type. All the attainable evidence points strongly to the conclusion that the age of these upper beds is Wealden. Professor Rogers mentions that they yield at Fredericksburg two or three species of ferns and stumps of Cycads of the genus Cycadeoidea. None of these have been seen by me (see p. 157; Reprint, pp. 44–45).[a]

This is, so far as I am aware, the first time that the Maryland cycads were referred to the genus Cycadeoidea.

Why the Older Potomac beds are not to be found in New Jersey underlying the Amboy clays or Raritan formation has been a difficult question. This latter formation rests unconformably upon the Triassic sandstones in most parts of that State with no indication of the Older Cretaceous beds at their base. The prevailing theory is that the later beds transgressed far to the landward beyond the margin of the older ones. This could be demonstrated only by borings far enough to the eastward to strike the older beds. The only such boring that has been made in which this theory received partial confirmation is that of the Jamesburg well. Jamesburg is about 9 miles from the Triassic border, in the direction of the dip. The well was bored by Mr. H. F. Walling in 1880 to a depth of 481 feet. The lower 26 feet were through coarse sand, white clay, and gravel, but it is not stated whether the clay was feldspathic. These materials may or may not belong to the Older Potomac.[b] This case can not therefore be said to solve the problem.

Another problem is to account for the absence of the Newer Potomac in Virginia, where in many places the Eocene (Pamunkey) and other later beds rest unconformably upon the Older Potomac. It has been supposed that they may have been eroded away before the date of the deposit of these last-mentioned beds. The artesian well bored by Gen. A. A. Humphreys, at Fort Monroe, from 1864 to 1869, to a depth of 907 feet,[c] lends some support to this view, as the lower 7 feet went through "reddish mottled clays," which are wanting in the Older Potomac and are characteristic of the Newer Potomac.

[a] Relative to this last statement I wrote to Professor Fontaine to inquire when and where Professor Rogers published it. He investigated the matter and replied that he must have been mistaken in attributing it to him, as he now knows of no evidence of cycads having been seen in Virginia. He doubtless naturally drew this inference from Professor Rogers's statement quoted above (see p. 347).

[b] See Ann. Rep. State Geologist of New Jersey for 1880, Trenton, 1880, pp. 166–167.

[c] The Virginias, Vol. III, October, 1882, pp. 151–152; Geology of the Virginias, pp. 733–735.

On January 7, 1883, Prof. P. R. Uhler delivered a lecture before the Naturalists' Field Club of Baltimore, an abstract of which was published the same year,[a] in which he discussed the "Geology of the Surface Features of the Baltimore Area." A considerable part of this abstract is devoted to what is now called the Potomac formation and which he characterizes as Upper Jurassic or Wealden. He gives the formation a thickness of 500 feet, refers in a general way to its fauna (then consisting only of the *Astrodon Johnstoni* of Leidy) and flora and offers the following description of the beds:

> The whole series of the beds having been derived from the comminuted or chemically altered elements of the Archean rocks, we find accordingly at the very bottom of the formation a stratum of micaceous sand mixed with finely ground mica and aluminous matter. This is arranged in superposed layers, the fine white clay alternating with the white sand until a thickness of 140 feet has been accumulated. Next above this is a layer of pale clay, 20 feet in thickness, followed by 6 feet or more of fine white sand. And so sands, clays, gravel layers, and three different strata of cobblestone drift, overlain by other coarse drift and bowlders set in red and pale clays, complete the series up to near the surface. Above these the gravel beds of the Glacial period, with perhaps still others from the Champlain epoch, rise in hills, or spread over the Wealden domes in deposits of varying thickness. To the Susquehanna River we must look for the broad avenue through which the general drift reached this area, charged with bowlders of fossil-bearing rocks torn from the mountains more than 70 miles distant.
>
> The Wealden formations were built in comparative quiet as sediments at the bottom of shallow water, and near the upper part of the series a thick stratum of white sandstone and conglomerate spread from the present shores of Chesapeake Bay away back to the Belair road near the Gunpowder River.
>
> The scattered remnants of this great sheet of stone may still be seen sticking out of the water in Rock Creek, at the mouth of the Patapsco River, and also in the soil of the region beyond White Marsh Run. The other end of this stratum passes across Magothy River, outcrops on the Severn, and reappears in a ravine near Collinwood, on the Popes Creek Railroad.

Professor Fontaine had now (1883) commenced making extensive collections of fossil plants from the Older Potomac of Virginia. My correspondence with him on the subject began with the beginning of 1883, and he kept me well informed as to his results from that time. On June 16 he visited Washington and brought a few of the archaic

[a] John Hopkins University Circulars, February, 1883, Baltimore, 1883, pp. 52–53.

dicotyledons, about which he had written me, for my inspection. In the fall of the same year I prepared a paper on Mesozoic Dicotyledons.[a] Having seen these forms from the Older Potomac, which I fully believed to represent ancestral dicotyledons, I inserted in this paper the following paragraph:

> It is to be hoped that we are at last approaching the beginning, at least, of a solution of this truly great problem of the origin of the dicotyledons. I have myself seen at least one slight, it may be, but very interesting sign of possible progress in this direction. Certain quite defective, but very instructive, specimens collected in the upper Jurassic of Virginia by Prof. William M. Fontaine, which he kindly brought to Washington for my inspection, certainly possess all the essential elements of dicotyledonous leaves, although at the same time bearing a certain recognizable stamp of the cryptogamic and gymnospermous vegetation that characterizes that earlier age. What is to be the final verdict of science upon these forms can not now be told, but it is to be hoped that the Mesozoic strata, not only in Virginia, but in all parts of the world, may be diligently searched and the materials carefully studied with a view to discovering these certainly merely "missing links" of a chain that can but have been once complete (see pp. 302–303).

In order that Professor Fontaine might more advantageously prosecute his researches and that the results might be published by the United States Geological Survey, arrangements were made by which he was attached to the staff of the Survey, and from that time forward his work was regularly reported by him. His first administrative report appeared in the Sixth Annual Report of the Survey (pp. 85–86), which bears date 1885, and gives an account of his manner of collecting these fossils. In this report he refers to one already submitted giving a detailed account of the geological relations worked out by him. The publication of this report was long delayed, but appeared in 1896, and will be treated under that date (see p. 393).

On June 9, 1885, I received instructions from the Director of the Survey to make investigations in the Younger Mesozoic of Virginia, and soon commenced field operations. About the same date Professor Fontaine submitted the manuscript and drawings of his work on the formation, for publication by the Survey, and it devolved upon me to edit the same.

On July 27, 1885, a reconnaissance of the formation was commenced, the party consisting of Mr. McGee, Professor Fontaine, and

[a] Am. Journ. Sci., 3d Ser., Vol. XXVII, April, 1884, pp. 292–303.

myself. After two days spent in the immediate vicinity of Washington we commenced the journey southward into Virginia. The plan was to follow the Younger Mesozoic belt, zigzagging frequently across it to examine its landward and coastward margins and the contact with both the underlying crystalline and Paleozoic rocks and the overlying Tertiary deposits. Thus by easy stages Fredericksburg was reached on August 4 and Richmond on the 8th. From Richmond an excursion was made in a rowboat down the James and up the Appomattox to Petersburg. Eight days were spent in this region, and on the 18th the southward journey was resumed in the attempt to trace the formation in that direction. The locality mentioned by Rogers on the Nottoway River at Bollings Bridge[a] as the most southerly point at which he had been able to find an exposure of the formation was visited, and it was found with characteristic clay balls in the bed of the river underlying the Eocene. The best exposure was close to Bollings Bridge, but it was also found at Fields Bridge, 4 miles above, which is undoubtedly Rogers's locality. The reconnaissance was continued to the Roanoke at Weldon, opposite which, near the railroad bridge, beds were found closely resembling those of the Older Potomac, but the exposures were not decisive on this point. The expedition then returned to Petersburg, Richmond, Fredericksburg, and Washington, varying the route as much as possible and examining many additional localities and exposures. The party reached Washington on the 25th, but resumed operations on the 27th and traversed the State of Maryland, following the Potomac outcrop as before. The iron-ore region was carefully examined, the only plant remains found being pyritized lignite and silicified wood. The cycadean trunks collected by Tyson, and then at the Maryland Academy of Sciences, were shown us by Prof. P. R. Uhler, president of the academy, and permission was given us to have photographs made of them, which was done a little later. Professor Uhler accompanied us to many localities with which he was familiar. Considerable time was spent on the coastward margin on the formation, where its relations to the overlying marine beds were studied. The reconnaissance was concluded on the 31st, a clear conception having been acquired by all the members of the party of the general nature of the Potomac formation.

[a] Report for 1839, p. 17.

During this reconnaissance the formation was constantly looked upon as a single geological unit with no presumed difference between its landward and its coastward margin, and it was often spoken of as a "trough" and compared to the Triassic beds farther inland. But before the expedition ended I suspected that this was not the case, and that the formation consisted of a series of beds of different age, those of the coastward side being younger than those of the landward side, and that these beds regularly ran under the overlying marine deposits. Among the facts pointing to this conclusion was the occurrence at Deep Bottom (called "Deep Hole" by Rogers[a]), the most easterly point on James River, of dicotyledons of higher and more modern types than the archaic ones of other beds. Also in the railroad cutting below Aquia Creek, and especially in a bank near this place, discovered by me, large numbers of leaves of unquestionable dicotyledonous type, afterwards mostly referred to the genus Sapindopsis Font., as perhaps related to the soapberry, were collected, and these beds are immediately overlain by the Eocene. More than this, our investigations on the Severn River revealed other and still higher types, resembling those of the Amboy clays.

Correspondence with Professor Fontaine was kept up during the fall and winter, and in one of his letters, dated February 12, 1886, he remarks:

> I do not think that I have ever told you about the collection I made at Brooke station after we parted. I am working up that material, and having looked carefully over all of it I can now give the results. This is the last of the material that I have on hand to study, and when I finish it I could take up Doctor Newberry's plants and bring the work to a close.
>
> I collected both in the railroad cut and from the bank first discovered by you. I was disappointed in not finding a number of new species of angiosperms, for nearly all of the impressions are of the pinnately compound leaf previously found. A multitude of these impressions were found, and among them a number of departures from the normal form. I found several new species of conifers and ferns, and several of the forms common at other localities in the Potomac terrane. Before I made this last collection I was troubled by the fact that at this locality, yielding unquestionable angiosperms, the other plants were in the main peculiar to this spot, and no forms like those occurring elsewhere and having a Jurassic type were seen. Although the stratigraphy and lithology indicated that the Brooke beds are of the same age as those of Fredericksburg and Dutch Gap, the possibility would obtrude itself that the flora here is younger than that found elsewhere.

[a] Report for 1840, p. 31.

He was then describing and drawing his Potomac plants, and as Doctor Newberry was at the same time engaged on his Flora of the Amboy Clays, it was thought desirable that we should all meet in consultation relative to these floras. Accordingly, on March 27, 1886, both Doctor Newberry and Professor Fontaine came to Washington, bringing numerous drawings of critical forms, and met me in council at the National Museum. The result was satisfactory, and there was no longer any doubt as to the much later age of the northern than of the southern beds.

Doctor Newberry had at the time under his charge at the Columbia University a collection of plants previously made by Mr. F. B. Meek at Federal Hill, in Baltimore, and it was arranged to lend the same to Professor Fontaine for determination, the results to be included in his forthcoming monograph. They were sent to him, and after a preliminary examination of them he wrote me under date of April 26, 1886, as follows:

> On examining the plants sent by Doctor Newberry I find that they are all of species that I already possessed, possibly one excepted, and which were collected by me at Dutch Gap and Fredericksburg. There are some 7 or 8 species, and they leave no doubt in my mind that the flora of the Baltimore clays is the same as that of the Potomac formation in Virginia. They certainly are quite different from the plants Doctor Newberry is studying from the Amboy clay of New Jersey.

A second reconnaissance and to some extent a collecting trip, was begun on June 8, 1886, the party consisting of Professor Fontaine, Dr. F. H. Knowlton, and myself, the means of transport being a steam launch. The object was to descend the Potomac River and visit all the important beds yielding plant remains that had been discovered in its bluffs or near the river, making collections at each point. It was further purposed to go up the James River as far as the Dutch Gap Canal, and points above, where Professor Fontaine had found promising localities, and to continue the work in this region. The programme was substantially carried out, the principal localities visited being Fort Washington, White House Bluff, Masons Neck, Quantico, and Aquia Creek, on the Potomac, and Trents Reach, the Dutch Gap Canal, and localities above, on the James. The extensive collections that were made were sent to the University of Virginia to be incorporated in the earlier ones of Professor Fontaine and worked up in his monograph, then far advanced. He spent the greater part of August, however, in Washington in order to make use of the larger facilities in the way of books and specimens in completing his work.

During October, 1886, I made some further collections of fossil plants from the Potomac beds at Federal Hill, in Baltimore. Professor Uhler also made collections there and all the new material was sent to Professor Fontaine.

The large amount of silicified wood and lignite occurring in the Potomac formation made it desirable to have it studied and determined so far as its structure would permit. Dr. F. H. Knowlton undertook this work in the fall of 1886, but was prevented by imperfect facilities from making as rapid progress as was desirable.

Mr. McGee, having been called upon by the health officer of the District of Columbia for some notes on the geology with reference to the quality of the subterranean waters, contributed a short paper, which was embodied in the report of that officer for the year 1884–85.[a] It was in this paper (p. 20) that the name "Potomac formation," which had been in general use by the geologists of the Survey, was first published.

Dr. F. H. Knowlton, who had been at work for nearly a year on the fossil wood and the lignites of the Potomac formation, completed his paper on that subject in June, 1887, and it was forwarded for publication by the Geological Survey on the 18th of that month. The publication was delayed and it did not appear till 1889.[b] Four new species of Cupressinoxylon (=Sequoia) and one of Araucarioxylon were systematically treated. The last named, however, was afterwards found to have come from the Trias.[c]

During the year 1886 and the first half of 1887 Professor Fontaine was engaged all the time he could find outside of his professional duties in describing and figuring the plants of the Potomac formation, of which he now had in hand an immense number. During all this time we kept up a correspondence, with interchange of specimens, books, etc., and he sent on lists of the names proposed for new species to be compared with the literature, which I had at that time so organized that it was easy to prevent the duplication of names. On July 1, 1887, the manuscript and drawings for the monograph were forwarded by him to the U. S. Geological Survey

[a] Report of the Health Officer of the District of Columbia for the year ending June 30, 1885, Washington, 1886, pp. 19–21.

[b] Fossil wood and lignite of the Potomac formation, by Frank Hall Knowlton: Bull. U. S. Geol. Surv. No. 56, 1889, 8°, 72 pp., 7 plates.

[c] See Twentieth Ann. Rep. U. S. Geol. Surv., Pt. II, 1900, pp. 264, 273.

for publication. At my request and in compliance with the general wish, Professor Fontaine prepared a summary of the most general conclusions growing out of his prolonged studies and submitted it to the biological section of the American Association for the Advancement of Science at its New York meeting in 1887. Only a brief abstract of it was published.[a] As this paper accurately reflects the views that prevailed at that time relative to the general character and probable age of the Potomac formation, I reproduce the parts bearing on these points:

> The name Potomac formation has been applied to a series of newer Mesozoic sands, gravels, and clays, sometimes cemented into sandstones and conglomerates, which appear along the inner margin of the coastal plain, forming the basal member of the undisturbed Mesozoic and Cenozoic formations of the eastern United States, in Virginia, Maryland, Delaware, and perhaps other States. It comprises two members—an upper, consisting generally of variegated clays which are well exposed about Baltimore, and a lower, consisting predominantly of sands and gravels, well exposed in the bluffs of the Potomac River below Washington. The upper member is known only north of Fredericksburg, and the lower is best developed from Washington to Richmond (see p. 275).
>
> The age of the formation, as indicated by its flora, appears to coincide approximately with that of the Lower and Middle Neocomian [misprinted Neuronian] of Greenland and Europe (see p. 276).

It was in December, 1887, that Mr. J. B. Hatcher, under instructions from Prof. O. C. Marsh, collected a considerable number of vertebrate bones from an iron mine near Muirkirk, Md. He also found in the same beds some small cones representing the genus Sequoia, and much silicified wood and lignite. The bones were described by Professor Marsh and the results published at once.[b] As to the geological significance of these forms, Professor Marsh says:

> The fossils here described, and others from the same horizon, seem to prove conclusively that the Potomac formation in its typical localities in Maryland is of Jurassic age, and lacustrine origin. There is evidence that some of the supposed northern extensions of this formation, even if of the same age, are of marine or estuary origin (see p. 94).

At about this same time Prof. P. R. Uhler, who had long been actively studying this formation in Maryland, published a somewhat extended

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[a] Proc. Am. Assn. Adv. Sci., 36th meeting, New York, 1887, Salem, 1888, pp. 275–276.

[b] Notice of a new genus of Sauropoda and other dinosaurs from the Potomac formation, by O. C. Marsh: Am. Journ. Sci., 3d ser., Vol. XXXV, January, 1888, pp. 89–94, 9 text figs.

paper on the general subject, which he first read before the American Philosophical Society in Philadelphia on January 6, 1888.[a] In this paper he not only proposed the name Albirupean for the upper beds, but he also proposed the name Baltimorean for the lower ones, i. e., to quote his words, "for the conspicuous clay formation which lies near the bottom of the alluvial column on the Archean rocks of Maryland" (see pp. 47–48). It must be remembered that all who had up to that date studied the formation supposed that nearly or quite all the beds in Maryland were higher than any in Virginia, and the term "iron-ore clays," used by Tyson, was used for the greater part of all this, although Professor Fontaine had observed that there were also gravels and coarse sands at places in that State. Whether Professor Uhler intended his Baltimore formation to extend into Virginia or not he does not say, and in this paper he says that the Rappahannock freestone is lithologically different from the white rocks of the Albirupean, which in fact is certainly the case. He represents the iron ore as occurring in the Baltimorean across the State in the form of pockets. His general description of the Baltimorean may profitably be reproduced here:

> The formation is made up of numerous strata, constituting altogether a column of alluvial matter more than five hundred feet deep. That part which we can examine at or near the level of the lower streets in South Baltimore exhibits a dark lead-colored compact clay, well stratified, and resting immediately upon a layer of dense iron clay-stone only a few inches in thickness. Often the clay which comes in direct contact with this stone is stained a bright red color, is of a very fine texture, and is known as "pudding-clay." On this the distinctly stratified layers of dark clay, ranging usually from seven to nine feet in thickness, are built, and consist of strata varying from three inches to fully two feet in thickness. Between the finely ground layers, in contact with the smoothest surfaces, we meet with the remains of trees, shrubs, vines, ferns, equisetæ, and, perhaps, algæ. These fossil remains occur in the greatest profusion, accompanied by finely reduced lignite in the upper strata. At least five such intervening plant-beds are present in the base of Federal Hill and its extension eastwards, in each of which some peculiar form of fern, vine, or leaf serves to distinguish it from the others. It has been my good fortune to discover these beds in this region, and to secure ample collections of all the remains at present found in them, and these are now being figured and described by Professor Fontaine, of Virginia.

[a] The Albirupean formation and its nearest relatives in Maryland, by P. R. Uhler: Proc. Am. Phil. Soc., Vol. XXV, pp. 42–53.

From the lowest layer I have taken out plants only of a low type of structure resembling algæ and nitellas; from the next layer above, equisetæ and ferns with strange vine-like structure; from the layer a few feet higher, buds and twigs of trees allied to the cypress and redwoods of California, as also leaves of ferns having the form of those of the Gingko; from the fourth layer other ferns, coniferous stems, buds, and scales, with some leaves of dicotyledons resembling sassafras; and from the upper layer leaves which resemble those of the hawthorn, magnolia, willow, and hemlock.

The less distinctly stratified clay overlying these is rich in lignite, often containing the trunks and limbs of nearly entire trees, some of which have been found with spruce-like cones and needle-shaped leaves.

The continuation of this bed upwards is composed of the iron ore clays which form such conspicuous hills and ridges along the road leading to Washington. In this member of the series lie the extensive layers of carbonate of iron, the richest of which occur near the base, while the nodules and oxidized lumps are found nearer the surface. The extension of this bed still higher, at various levels, displays the red and white variegated clays, such as we see in large areas in crossing the country south and east of the iron ore hills (see pp. 48, 49).

It was remarked that the cycadean trunks collected by Tyson in Maryland were deposited in the museum of the Maryland Academy of Sciences. It was there that our party saw them in 1885 and had photographs of them made, to illustrate Professor Fontaine's monograph of the Potomac flora. After the organization of the museum of the Johns Hopkins University the Maryland Academy, being obliged to contract its quarters, donated its paleontological collections to the university. The cycads were transferred among the rest, and are still there. Prof. Wm. B. Clark gave an account of the transfer in 1888,[a] with appropriate acknowledgments.

The first of Mr. McGee's papers describing "Three Formations of the Middle Atlantic Slope," published early in 1888,[b] is chiefly devoted to the Potomac formation. From it we learn that he had extended his investigations much farther to the northeast than had been reached by the expedition of 1885, and had studied the contact of the coastal plain with the underlying older rocks through Delaware and Pennsylvania into New Jersey. He referred the "Bryn Mawr gravel" (p. 130), the "ferru-

[a] Johns Hopkins University Circulars, Vol. VII, No. 65, April, 1888, p. 67.

[b] Three Formations of the Middle Atlantic Slope, by W J McGee: Am. Jour. Sci., 3d ser., Vol. XXXV, February, 1888, pp. 120–143; April, 1888, pp. 328–388; May, 1888, pp. 367–388; June, 1888, pp. 448–466, pls. ii and vi.

ginous conglomerate" of C. E. Hall (p. 131), the "yellow rocks" above Trenton (p. 132), and the "sand hills" east of Princeton (p. 132), all to the Older Potomac. That the Older Potomac does occur in Pennsylvania, however, there is no doubt, and some of Mr. McGee's identifications were correct.

The discoveries of vertebrate remains in the Potomac of Maryland by Mr. Hatcher greatly interested Professor Marsh, and he was anxious to know what the vegetable remains indicated. He was aware that large collections of plants had been made and were being worked up, and he came to Washington in January, 1888, to consult with those who were acquainted with the subject. It chanced that Professor Fontaine was here at the time and there was a general conference on matters relating to the Potomac formation. I had sent the cones collected by Mr. Hatcher to Professor Fontaine and received from him an interesting letter about them, dated January 5, 1888, which contains much that had not then and has not since been made public. I therefore quote somewhat fully from that letter:

> I am glad that you sent the cones for my inspection. I should say that they are certainly cones of Sequoia. I think that the more elongate and smaller cones are identical with cones of Sequoia that I found at Brooke station. You will find some of these figured in the Potomac Flora. Most of those that I found were imprints that were formed of cones that retained only a few scales, and the cones were more or less flattened by pressure. Your cones are much more perfectly shaped, although probably somewhat elongated by pressure. I did not give mine specific names because they were not attached to leafy branches, and I had named a number of species that had been determined by very perfectly preserved leafy twigs. I thought it probable that these cones belonged to some of the species named from the branches. The larger, rounded, brownish-colored cone among those you sent may be of the same species with the rest, but it is exactly like cones that I found at Dutch Gap attached to leafy branches of *Sequoia ambigua* Heer, which is the most common Sequoia at that place. I remember also that among the specimens collected by Mr. McGee at the head of Chesapeake Bay, those that you showed me, and which contained hardly anything but angiosperms, I saw a fragment of *S. ambigua*. My new genus Athrotaxopsis has on branches closely resembling Cyparissidium, cones strikingly like those of Sequoia, but the scales have only one comparatively large seed under each. Then, too, Sphenolepidium has cones in outward form much like these. Sequoia, Athrotaxopsis, and Sphenolepidium are abundant in the Potomac of Virginia, and I find some of these Sequoias in the Tuscaloosa formation. They appear to be persistent and widely diffused forms.

It is not strange that Mr. Knowlton finds Cupressinoxylon, for I find at least six abundant and widely diffused species of Sequoia, determined, without taking the cones into consideration. I think it highly probable that the genera Sequoia, Athrotaxopsis, and Sphenolepidium had wood closely alike, and that the trees grew in forests and furnished most of the vast quantity of lignite that occurs in the Potomac.

After Professor Fontaine had left Washington it occurred to Professor Marsh that a paper on the flora of the Potomac formation and its geological significance ought to be presented to the National Academy of Sciences at its April meeting in Washington, and, as president of the academy, he invited me to present it. I assured him that Professor Fontaine was the proper person to do this, and I made every effort to induce him to do so, but he declined on several grounds, and the duty devolved on me. He authorized me to make any use I thought best of his manuscript, which was then in my hands, and it was from this that most of the facts used by me were drawn. I could do this the better, as, at Professor Fontaine's request, I had prepared the three tables of distribution which form the concluding part of the published monograph. From the data thus before me I prepared the paper which I read before the National Academy of Sciences on April 20, 1888.[a]

Professor Marsh in describing the vertebrate remains had expressed himself so emphatically on the Jurassic affinities of the fauna that it was natural that I should inquire particularly into the question whether the flora could be regarded as confirming, or as not distinctly negativing, that view. The dicotyledons presented the chief obstacle, this subclass never having thus far been found below the Urgonian, and only one species as early as this. But the Cretaceous dicotyledons thus far known are fully developed, often belonging to genera still living, and it was clear to me that this proved an extensive break in the record. It was this point that I strove chiefly to bring out in this paper, and after fully discussing it I gave my conclusions in the following form:

On numerous occasions, dating as far back as 1878, I have expressed the opinion that the dicotyledons could not have had their origin later than the middle Jura, and it will not surprise me if the final verdict of science shall place the Potomac formation, at least the lower member in which the plants occur, within that geologic

[a] Evidence of the fossil plants as to the age of the Potomac formation: Am. Journ. Sci., 3d ser., Vol. XXXVI, August, 1888, pp. 119–131.

system. While the remaining types point strongly in this direction, I do not regard the dicotyledons as at all negativing, but even more strongly suggesting, this view.

Still, it may be admitted that, according to the ordinary modes of arguing from similar statistics, the sum of all the facts here presented would make the Potomac, considered from the point of view of the flora alone, homotaxially equivalent to the Wealden of England and north Germany, now usually included in the Cretaceous system. If the vertebrate remains are Jurassic and the flora Cretaceous we only have here another confirmation of a law exemplified in so many other American deposits, that, taking European faunas and their correlated floras as the standard of comparison, the plant life of this country is in advance of the animal life. This law has been chiefly observed in our Laramie and Tertiary deposits, but is now known to apply even to Carboniferous and Devonian floras. It is therefore to be expected that we shall find it to prevail during the Mesozoic era. If, therefore, it be really settled that the fauna of the Potomac series is homotaxially Jurassic, and we take our starting point from the Old World geology, there will be no more objection to regarding the Potomac flora as Jurassic than there is now in contemplating the Laramie flora as Cretaceous. In fact, so far as the character of the flora is concerned, there is much less difficulty in the case of the Potomac than in that of the Laramie, since, as I have shown, the Potomac flora, viewed in all its bearings, can not be said positively to negative the reference of the formation to the Jurassic upon the evidence of the plants alone.

I do not, however, desire to be understood as arguing for the Jurassic age of the Potomac formation. The most that it is intended to claim is that, if the stratigraphical relations and the animal remains shall finally require its reference to the Jurassic, the plants do not present any serious obstacle to such reference (see pp. 130–131).

As it has since been made clear that the vertebrate remains are not conclusive as to the Jurassic age of the beds in Maryland and agree quite as well with the assumption of a Lower Cretaceous, or at least a Wealden age, there is even less difference between the evidence of the flora and that of the fauna than was then supposed. Nevertheless I see no reason to qualify the statements then made. There was some discussion of my paper, Doctor Newberry denying the possibility of the formation being Jurassic, and Professor Cope concurring in this view. I sent a copy of my manuscript to Professor Fontaine, saying in my letter accompanying it, dated May 21, 1888:

I do not think that a proper understanding of my remarks commits me at all to the Jurassic theory. It is true I say more about that than the other, but it is because it had been assumed that a flora with so many dicotyledons must of necessity be Cretaceous. All I aimed to prove was that this was not a *necessary* conclusion,

and I intended to leave it so that if the stratigraphy and the animal remains required its reference to the Jurassic the plants would not present any serious obstacles to such a reference.

In his reply, under date of May 24, 1888, he makes a substantial contribution to the discussion, which should be published. He says:

I did not attempt to express the evidence in the form of percentages, because I thought that this form might give undue weight to those types that are represented by a considerable number of species which are, however, found at but few places, and have very few individuals. I was disposed to give more weight to such a species as *Dioonites Buchianus* than would appear from its single species, for this form is widely diffused and immense in the number of individuals. The same is true of others of the species identical with known Neocomian forms.

You might have made out the case for antiquity even stronger, if you had called attention to the large number of peculiar types, such as the broad-leaved conifers, and others, which are so largely developed in the Potomac, but show no trace in the Cenomanian. I think your exposition of the evidence is a very just one, and I do not understand you as committed to a Jurassic age.

In another letter, dated June 14, 1888, he further says:

I received a letter from Doctor Newberry not long since about the Potomac flora and its age. He seemed to think that you argued for the Jurassic age of the Potomac, and this seems to be Mr. McGee's notion also. I do not understand your paper so to argue. It is plain that it goes to show that the sum of the evidence from the plants, as it now stands, points to the Wealden or Lower Neocomian age of the beds, but that there is no evidence incompatible with an Upper Jurassic age.

This in my opinion is the correct view, with the modification that I would make the age range through the Urgonian.

I do not think that Professor Marsh's dinosaurs mean anything more than Wealden. The Wealden vertebrate fauna is in part dinosaurian. Professor Marsh said that a number of the species were allied to those of his Atlantosaurus beds, and these he called Wealden. Doctor Newberry says that all of Professor Marsh's Potomac species are new, and hence do not necessarily prove Jurassic age. He (Newberry) maintains either that the Maryland and Virginia beds are different or that they are not older than Lower Cretaceous [Neocomian I suppose he means].

Prof. P. R. Uhler, who is the best informed person now living in relation to the early geological work of Maryland, and especially as to the localities at which the cycadean trunks collected by Tyson were found, made in 1888 the following statement on this subject, which may be relied upon:

Rarest, of great value, and still unrepresented in any other collection, are the stumps of Cycads presented to the Academy by Mr. P. T. Tyson. All of these were taken from the Upper Jurassic clays of Maryland. One specimen came from the

iron-ore beds of Mr. J. D. Latchford, near Muirkirk, a second from the vicinity of Hyattsville, and a third from similar clays next the shore of the Patapsco River at the Spring Gardens, south of Baltimore.[a]

The statements that had thus far been publicly made relative to the Potomac flora aroused a lively interest among European paleobotanists. There was more or less correspondence with Saporta, Schenk, Nathorst, and Feistmantel, and the last-named author wrote to request further particulars. His letter was referred to Professor Fontaine, who, under date of March 12, 1889, prepared a somewhat full statement of his views relative to the significance of the dicotyledons. A copy of this was sent to Feistmantel, who made it the subject of a paper read before the Royal Bohemian Society on April 12, 1889, and published in its proceedings.[b]

He had already published[c] a letter on the subject which he wrote to Dr. Ernst Weiss after receiving Professor Fontaine's notes, but in this he does not enter so fully into the discussion.

Proofs of Professor Fontaine's monograph were corrected in the spring and summer of 1889, and the work, although it bears date 1889,[d] did not appear until 1900.

In this work was laid a solid foundation for the subsequent study of the Potomac formation. In it are described and thoroughly illustrated 365 species of fossil plants. If we exclude the dicotyledons, of which only 75 species were found, every class represented greatly exceeds in number of species the same class in the present living flora of the same territorial area. That is to say, there are many more Potomac than present living ferns and conifers, while the large cycadaceous flora of that age is wholly wanting at the same latitudes to-day. But undoubtedly the most interesting fact is the occurrence at this remote epoch of the first sketches of nature of that great race of plants, the dicotyledons, which now form 75 per cent or more of all vascular plants.

The work contains three tables of distribution, prepared by myself,

[a] Sketch of the history of the Maryland Academy of Sciences, by P. R. Uhler: Trans. Maryland Acad. Sci., Vol. I, Dec. 19, 1888, pp. 1–10. See pp. 7–8.

[b] Ueber die bis jetzt ältesten dikotyledonen Pflanzen der Potomac-Formation in N. Amerika, mit brieflichen Mittheilungen von Prof. Wm. M. Fontaine, von Ottokar Feistmantel: Sitzb. d. k. böhm. Ges. d. Wiss., Jahrg, 1889, Vol. I, pp. 257–268.

[c] Ueber die bis jetzt geologisch ältesten Dikotyledonen, von Herrn O. Feistmantel: Zeitsch. d. deutsch. geolog. Ges. Berlin, Vol. XLI, 1889, pp. 27–34.

[d] The Potomac or Younger Mesozoic flora, by William Morris Fontaine: Mon. U. S. Geol. Survey, Vol. XV, 1889; text, xiv, X 377 pages; atlas, 180 plates.

at Professor Fontaine's request, from his manuscript, the first giving the localities in the formation from which each species was collected; the second giving the distribution of all the species hitherto known from other beds in all countries, and also of those species most closely allied to Potomac forms; and the third showing the formations in their ascending geological sequence from which Potomac species and species allied to them have been obtained. Professor Fontaine discussed the age and general character of the Potomac flora in the concluding portion of the work. He thinks that much of the confusion that exists relative to age arises from the use of terms in different senses, and especially from that of the term Wealden. On this point he says:

> Before the examination of the geological relations of the Potomac flora is undertaken it will be well to define in what sense the names of certain geological formations, to which frequent reference must be made, will be taken in this memoir. The two formations which are capable of misconception are the Wealden and Neocomian. By some the Wealden formation is regarded as an independent group forming the uppermost member of the Jurassic. Others regard it as a series of beds contemporaneous with a portion of the lower Neocomian, formed in estuaries and marshes at the time when a portion of the typical lower Neocomian, which is marine, was being deposited in the sea. The latter view is the one assumed in this memoir.
>
> In this work the Neocomian period is taken as including the Urgonian and Aptian of D'Orbigny, the former being, when present, the middle member and the latter the upper member of the formation. When, then, reference is made to Neocomian plants, fossils of the Wealden, Urgonian, and Aptian groups are included and not distinguished (see pp. 331–332).

He then takes up the several classes, families, and genera, and considers the bearing of each on the age of the beds. His final conclusion is as follows:

> This being true, we should expect to find in any large collection of Neocomian plants a great mingling of types. We should find the survivors of the old floras and the newly arrived precursors of the more recent ones mingled with a number that attain their development in and are peculiar to the Neocomian. This is exactly what we find to be true of the Potomac flora. That so many of these plants are new is perhaps to be explained, in part at least, by the fact already mentioned, that the flora of this epoch is very poorly represented and comparatively but little known. It is not possible to say positively to what precise epoch of the Neocomian the Potomac belongs. Its flora ranges from the Wealden through the Urgonian, and probably includes some Cenomanian forms (see p. 348).

Doctor Knowlton's bulletin, already mentioned, on the fossil wood and lignites, appeared in advance of Professor Fontaine's work. Doctor

Knowlton had read at the Cleveland meeting of the American Association for the Advancement of Science, 1888, a summary of his results, an abstract of which was published in the proceedings,[a] and also in the American Geologist.[b]

Professor Uhler published another paper during 1889,[c] which, though chiefly devoted to the description of Eocene shells, discusses the geological relations of the Cretaceous beds and finds the Albirupean in the bluffs below Fort Foote, on the Potomac, overlying the beds which, a few hundred yards above, viz, at Rosiers Bluff, have yielded a large flora belonging to the Aquia Creek series or upper horizon of the Older Potomac. In a later paper[d] he gives a section on Piscataway Creek showing the same beds (pp. 103–104).

Prof. William B. Clark, in his account of the "Third Annual Geological Expedition into Southern Maryland and Virginia,"[e] recognizes Uhler's Albirupean as distinct from the underlying Potomac.

Mr. N. H. Darton had been for some time engaged on the areal geology of the District of Columbia and parts of Maryland and Virginia in which the Potomac formation occurs. He did not cooperate with the paleontologists, nor, so far as I am aware, consult them, but he accepted the name Potomac formation, which he did not further subdivide in coloring his maps. He read a paper before the Geological Society of America at its meeting in December, 1890, on the general geology of this region,[f] in which he named and described the overlying marine deposits (Severn, Pamunkey, Chesapeake) and discussed the Potomac, but added nothing to the knowledge of it that had been gained by others.

At my request, Professor Fontaine undertook the determination of the plants described by R. C. Taylor in 1835 (see pp. 344–345) from the figures given on his plate, and he communicated the results to me in a letter dated May 17, 1891. As this paper was overlooked by him in preparing his monograph, and no one has attempted to determine

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[a] Vol. XXXVII, Salem, 1889, pp. 207–208.

[b] Vol. III, No. 2, February, 1889, pp. 99–106.

[c] Additions to observations on the Cretaceous and Eocene formations of Maryland, by P. R. Uhler: Trans. Maryland Acad. Sci., Vol. I, pp. 45–72.

[d] Notes and illustrations to "Observations on the Cretaceous and Eocene formations of Maryland:" Ibid. June 7, 1890, pp. 97–104, pl. A.

[e] Johns Hopkins University Circulars, Vol. IX, No. 81, May, 1890, pp. 69–71.

[f] Mesozoic and Cenozoic formations of eastern Virginia and Maryland, by N. H. Darton: Bull. Geol. Soc. Am., Vol. II, April 14, 1891, pp. 431–450, pl. xvi.

these forms, which were the earliest obtained from the formation, it is of interest to see precisely what they were, so far as can be ascertained without access to the specimens themselves, whose whereabouts is now unknown, if, indeed, they were preserved at all. I therefore give the list with the names used by Taylor, his figures, and Professor Fontaine's identifications:

Lycopodiolithes ? sp. Taylor: Trans. Geol. Soc. Pennsylvania, Vol. I, Philadelphia, 1835, p. 321, pl. xix, fig. 2. Probably a cast or stem of *Frenelopsis ramosissima* Font.

Lepidodendron sp. Taylor: Ibid., p. 322, fig. 1. Sphenolepidium Sternbergianum (Dunk.) Heer.

Sphenopteris sp. Taylor: Ibid., fig. 3. Scleropteris elliptica Font.

Pecopteris ? sp. Taylor: Ibid., p. 323, fig. 4. Cladophlebis constricta Font.

Thuites ? sp. Taylor: Ibid., fig. 5. Sphenolepidium dentifolium Font.

Sphenopteris sp. Taylor: Ibid., fig. 6. Cladophlebis constricta Font.

In May, 1891, I resumed the study of the Potomac formation, assisted to a considerable extent by Mr. David White, and accompanied on some of the excursions by Mr. Robert T. Hill, Prof. P. R. Uhler, and others. On June 13 I discovered the important locality for fossil plants in Rosiers Bluff, above Fort Foote, and made the first small collection from there. The exact locality is 200 yards below Notley Hall wharf, on the Fort Foote reservation. The clays rise here about 60 feet above the river and occupy in the highest place all but a few feet of cobble and surface gravel. They are varied in color, largely variegated red and white, but often with more or less lenticular layers of blue, brown, and darker. They are interstratified with sand, gravel, and ferruginous shales. The plants were found about 30 feet above the water, in a thin stratum of bluish clay, between two seams of coarse sand.

On June 20 I made the following section of the exposure discovered by me in 1885 near Aquia Creek, from which so many dicotyledonous forms were subsequently collected, and which is designated by Professor Fontaine in his monograph as "Bank near Brooke:"

Section of the bank near Brooke.

	Feet.
4. Fine-grained and laminated white, blue, and buff clays yielding the fossil plants and extending to the roots of the small trees, shrubs, and herbage covering the hill	12
3. White ferruginous sands, frequently cross-bedded, with very little interstratified clay, covered at the base, but traceable to near the bottom of the ravine	24
2. Pack sand in gulch at bottom of ravine	2
1. White clay streaked with pink and red at bottom of gulch	2
Total exposure	40

This is a much thicker and better section than could be measured in the railroad cuttings near by, rising as high as any of these and reaching far below the railroad bed. It is all included in what I afterwards called the Aquia Creek series (Brooke beds of Fontaine).

Investigations in the District of Columbia, Maryland, and Virginia were continued through July and August, 1891, and the general relations of the Potomac beds to one another and to the ones below and above were somewhat thoroughly worked out. A number of localities for fossil plants were discovered. Much grading of streets was being done to the northwest of Washington and some fine sections were made under circumstances that will never occur again. The Potomac, where it occurs at all, is of course thin in that region, but contacts with the underlying Algonkian were often exposed.

On November 25, assisted by Mr. David White, I made the principal collection of fossil plants from the Rosiers Bluff locality, discovered on June 13. The bed is limited in range, being about 5 feet thick and less than 150 feet long on the river front. We worked five hours and obtained a large number of specimens. We found the plant-bearing stratum to be 4 or 5 feet thick and 30 or 40 yards long. A few, however, were found much higher. The cycads and conifers occurred mainly in the lower and the dicotyledons in the higher portions.

During the summer of 1891 the entire collection of fossil plants used by Professor Fontaine in preparing his monograph was shipped from the University of Virginia to Washington and installed in the National Museum.

Dr. C. A. White, in his correlation paper on the Cretaceous,[a] 1891, treats the Potomac formation under the Atlantic border region of Maryland, the District of Columbia, Virginia, and North Carolina. He seems not to have made personal investigations and confines himself to a review of the literature. As regards the occurrence of the Older Potomac in North Carolina, there still remain doubts, most of the Potomac beds thus far discovered in that State belonging to the upper division and no characteristic fossil plants have been found. There is, however, reason to suppose from lithological and stratigraphical considerations that the beds forming the bluffs of the Cape Fear River

[a] Correlation Papers, Cretaceous, by Charles A. White: Bull. U. S. Geol. Surv. No. 82, 1891, pp. 88–92.

at Fayetteville and for some distance above and below belong to the lower division (see p. 390).

In Professor Uhler's Albirupean Studies,[a] 1892, he makes the clearest distinction thus far drawn between the upper and lower beds of what is now included in the Potomac formation, and he insists upon their stratigraphical unconformity. His description of the beds in Maryland and New Jersey is clear and not open to serious criticism, but his discussion of the Virginia deposits is somewhat ambiguous and led some to think that he intended to include the freestone in his Albirupean. To enable anyone to judge for himself his own words should be quoted. They are as follows:

> My own studies of the deposits at Fredericksburg, Va., and other places between that city and Mount Vernon, induce me to take a very different view from Professor Fontaine of the structure of the region, and of the position held by the fossil plants in the order of their succession in time.
>
> The following facts have influenced my belief in the theory of succession of the strata or beds and their contents. The lowest iron-ore clays, at the base of which the most archaic types of Angiosperms occur, are those beneath Federal Hill and its connections in Baltimore. The same series of clays is identifiable in many places all the way from near the North East River, at the head of Chesapeake Bay, to the District of Columbia. Local areas of similar clays which have not yet yielded their characteristic plant fossils occur in Virginia, west of the Potomac River. Near Falmouth and at at a few points between that place and Fredericksburg, Va., are clays of the same plastic type and structure as those in Federal Hill.
>
> They do not agree in composition and structure with the hollow or lens in the streets of Fredericksburg, from which Professor Fontaine and myself excavated so many fossil leaves, twigs, etc.
>
> The Fredericksburg deposit is, to my view, a structure built at a much later date than the Falmouth clays, and the series of strata to which it belongs has been built within an eroded area. The sandstone member of the Aquia Creek region, as seen below Fredericksburg and everywhere else in Maryland and Virginia, is a whole formation higher than the aforesaid clays. * * *
>
> The Albirupean appears, and extends at least from the border of the Triassic region, north of Raritan Bay, across New Jersey, Delaware, and Maryland to below Fredericksburg, Va. (see pp. 193–194, 199).

It is true, as already shown, that the Aquia Creek or Brooke plant-bearing beds are above the Fredericksburg beds, and the freestone, which occurs at the railroad bridge across Aquia Creek, may be seen

[a] Albirupean studies, by P. R. Uhler: Trans. Maryland Acad. Sci., Vol. I, June 8, 1892, pp. 185–201.

to run under it to the south, but even this is much older than the beds on the Severn River in Maryland in which occur his type sections of the Albirupean.

My own studies in the formation were resumed with the opening of the field season of 1892. Early in May Mr. David White accompanied me on an excursion to Fredericksburg and the region adjacent. We first studied the contact of the Potomac with the underlying crystallines on the Rappahannock, on Fall Run above Falmouth, and on Hazel Run to the south of Fredericksburg, and usually found a bed of clay underlying the freestone. A number of instructive sections were made. Above the freestone occur heavy beds of loose sand. We then followed the Rappahannock down in a rowboat from Fredericksburg to the Eocene contact at the Marl Mill, 6 miles below. This affords a fine section. The dip to the southeast is about 50 feet to the mile and the distance in a straight line from the crystalline contact to the Eocene contact is about 6 miles, giving the Potomac a thickness of 300 feet. We were able to measure only a little over 200 feet, but there was evidence of erosion at several points. The 200 feet measured were as follows:

Section of the Rappahannock River at and below Fredericksburg.

	Feet.
3. Loose argillaceous, mostly white or yellowish, sand with thin clay seams, becoming darker and lignitiferous above, and unconformably overlain by the Eocene (Pamunkey) marl	50
2. Coarse, feldspathic, conglomeratic sandstone with lenses, nodules, and pellets of fine white clay, and with casts and molds of stems, logs, and indeterminable plants	100
1. Red, pink, and purple to white clay, carrying lignite and (on Fall Run) lignitized logs; resting unconformably upon the crystalline rocks	50
Total exposure	200

The clay disappeared beneath the water of the river opposite Pratts Rock, the sandstone 3 miles below that point, the sand at Travelers Reach, and the last of the darker lignitic beds half a mile above the Marl Mill. Back from the river the higher country in all directions from Fredericksburg is covered with a relatively modern deposit, probably the Lafayette, while the bottom lands usually show a bed of Columbia brick clay. For these reasons the geological map of this region is colored for these formations only, giving no proper idea of the geology.

Leaving Fredericksburg on the 5th we explored the general region to the north as far as Stafford Court House along the western margin and found the clays almost everywhere underlying the sandstone. We

then examined the eastern margin of the belt all the way to the Potomac River and found the argillaceous sands and white stratified clays uniformly overlying the sandstone and overlain in turn by the marls. The conclusion became irresistible that for this entire region this is the normal order of deposition. This view is abundantly confirmed by the plant remains found respectively in the lignitic clays on Potomac Creek west of the Telegraph road and in the upper clays near Aquia Creek, which differ widely in character and indicate a great time interval between the earlier and the later deposits. The beds in this region are thicker than in the valley of the Rappahannock, the erosion having been less. Measuring as carefully as possible, we arrived at the following approximate section for any line drawn across the belt perpendicular to the strike, as, for example, on Potomac Creek or Accokeek Creek:

Section of Accokeek Creek.

	Feet.
3. Loose sands interstratified with white laminated clays carrying plants of high rank, such as Sapindopsis and other undoubted dicotyledonous genera	100
2. Coarse feldspathic sandstone becoming workable freestone	150
1. Lignitic clays carrying the older types of plants (ferns, cycads, conifers, and archaic dicotyledons)	50
Total exposure	300

Attention was next turned to the northern extension of the Potomac beds, and two months were spent in their systematic study. Following first the landward margin in the District of Columbia and Maryland, we soon discovered that less difference exists between the beds here and those of Virginia than had been supposed. The old idea of an "Upper Clay member" in Maryland, as opposed to a "Lower Sandstone member" in Virginia, was now wholly dispelled, the Virginia beds having been found to begin and end as clays and the sandstone to occupy an intermediate position. It was now found that in Maryland also wherever the deposition is normal (i. e., no transgression of higher beds) the basal member is clay and the succeeding one is, if not sandstone, at least very arenaceous and often lithified. Moreover, this second member in Maryland, although usually reddish from iron oxidation that has filtered into it from the overlying iron ores or from iron constituents of its own, usually contains casts and molds of stems, logs, and plants wholly similar to those of the Rappahannock sandstone, and these beds must be stratigraphically the same in both States. This condition of things with slight variations extends entirely across the

State of Maryland and was found at hundreds of exposures from Washington, D. C., to Wilmington, Del. Farther north the basal clays often assume a lilac hue, but do not otherwise differ from the purer (non-lignitic) basal clays of Virginia.

On the opposite or coastward side of the Potomac belt the conditions in Maryland are very different from those of Virginia. Here, everywhere northeast of the Potomac River, there are heavy beds more recent than any of the Potomac beds of Virginia holding the higher types of dicotyledonous plants similar to those of the Amboy clays. These beds always underlie the marine Cretaceous deposits (Severn, Matawan), or Tertiary (Pamunkey, Chesapeake), and usually rest on variegated clays. As the consideration of these upper beds, which I call the Newer Potomac, and which are probably to be correlated with the plastic clays or Raritan formation of New Jersey, as well as with the Tuscaloosa formation of the South, is deferred for the present, I will confine myself here to the beds that underlie them and certainly belong to the Older Potomac.

Between the coarse lithified sands above described as the probable homologue of the Rappahannock freestone and the higher beds last mentioned there occur in Maryland a series of beds which can not be compared lithologically with anything found in Virginia, and as at that time (1892) no fossil plants except silicified wood, lignite, and cycad trunks had been found in them it was difficult to correlate them. They contain below iron-stained clays and sands, iron ore, both white and red, pockets of lignite, and some sand and gravel, and above variegated clays of all shades and descriptions, interstratified with fine sand, and have a thickness of some 300 feet. At Federal Hill in Baltimore a more complete exposure of most of the Potomac beds of Maryland could be worked out from the various clay pits there than is to be found at any other point, and the section here was carefully made and has been published. Most of the plants taken from this locality were regarded by Professor Fontaine as representing his Brooke flora and coming from the upper part of the Older Potomac, but after examining the later collections made there in the light of other collections from Maryland he has now changed his mind and refers all the Federal Hill beds to the Rappahannock series.

We paid special attention to the contact of the Potomac with the crystalline and Paleozoic rocks in southeastern Pennsylvania and along the Delaware State line, because it was here that Mr. McGee had reported basal Potomac gravels and arkose. Near Brandywine Summit are extensive beds of feldspathic rock which are worked for kaolin. This occurs both as lithified and as decomposed feldspar, and the latter might easily be confounded with Potomac arkose, especially when partly mixed with Bryn Mawr and Chestnut Hill gravels, as it is in the region above Media, Bryn Mawr, and Conshohocken. Northeast of Conshohocken at a village called Cedar Grove, there are extensive gravel, sand, and clay pits. The Chestnut Hill gravel is here quite thick and pure. It usually rests on the crystalline rocks, which are often decomposed, forming pure kaolinic sands or clays of great thickness. At a few points, however, the gravels rest on mottled clays, which are probably Potomac and possibly basal Potomac. Sometimes pure sand extends below these which seems to be basal Potomac sand. At one place the lowest clays exposed were dark blue-black and full of small pieces of lignite. The Trenton marble crops out at Cedar Grove and is quarried there, and mottled clays were found resting on the limestone. That these beds represent the Older Potomac seems tolerably certain.

We also made a somewhat careful examination of the "yellow rocks" on the left bank of the Delaware above Trenton in New Jersey. They are conglomeratic and, except in color, appear to be identical with the conglomerates of the Trias as exposed in many places from Saltenstall in Connecticut to Culpeper, Va. In a deep ravine they were found shading off into regular red Triassic sandstone or brownstone, and there can be little doubt that they are wholly Triassic and not at all Potomac.

We were equally unsuccessful in our search for Older Potomac materials at the well-known "Sand Hills" of New Jersey. These hills consist of a trap ridge overlain by a superficial deposit of varied character, but that it can not be Potomac is proved by the fact that at lower levels, and especially at Tenmile Run Corners, it was found resting unconformably upon the plastic clay of the Raritan formation.

On September 18, 1892, two plant beds were found in the new reservoir at Washington, yielding numerous ferns and conifers. This reservoir

was excavated chiefly in a heavy bed of Rappahannock sand in which much silicified wood occurs. Several of the specimens treated by Doctor Knowlton were obtained from this locality, and one immense log was uncovered on the west side near the shaft, which has never been taken out and is now walled in. At this date the bottom of the reservoir was mostly dry, except for the stream from what was called the Capitol Spring, which coursed through it. Below this bed of sand is one of lignite, and this could then be traced all the way round the reservoir. It was seen to thicken somewhat on the west side. About midway of the reservoir from north to south, but on the east side, a little north of opposite the shaft and as much south of opposite the Capitol Spring tower, therefore only a short distance from the extreme southwest corner of the Soldier's Home inclosure, a few feet above the lignite bed, I found in a stratum of sandy clay quite abundant remains of plants, chiefly ferns, and, as it proved, nearly all belonging to one species (see p. 516). The vegetable matter was black, but tended to peel off.

Crossing to the west side, near the shaft I found another plant-bearing vein consisting of buff-colored clay with sand partings, and very frail. It held remains of conifers, cycads, and Gingkoaceæ (see p. 516).

About two weeks later, on October 2, 1892, I took Doctor Arthur Hollick to this locality and we made a small collection near the spot first described, but we must have worked in a different vein, for nearly all the specimens consisted of tubers of Equisetum.

In October, 1892, I spent six days in reexamining the Potomac beds on the James and Appomattox rivers. I was specially interested to see if any basal clays could be found, as all the plants collected by Professor Fontaine had come from clay lenses in the coarse sands. That these lenses must have been parts of an underlying clay stratum was self-evident, but the latter seemed to have been entirely eroded away before the deposition of the sands, and only a few remnants left in the form of lenses, the sand underlying as well as overlying them. These clay lenses become numerous in descending the James after passing Warwicks Park, some 7 or 8 miles below Richmond. At Drurys Bluff they are prolonged into strata varying in color, but clearly included in the coarse sands. They here rise 15 or 20 feet. Below Kingsland, Proctor Creek, and Red Water

Creek the coarse sands appear to rest on the granite. Nowhere could I find the basal clay forming a bed below the sands.

The high bluffs on the left bank of the Appomattox at Point of Rocks show the sands more thorougly lithified than at any other point in the Potomac formation. In fact they are very hard and resemble quartzite, and also resemble the white rocks for which Professor Uhler named his Albirupean formation, but, unlike these, and agreeing in this respect with the Rappahannock freestone, they contain small clay inclusions. No signs of the Potomac could be found above Richmond or Petersburg, but the Tertiary beds extend far up the James and rest on the crystalline rocks.

On October 16, 1892, I discovered chocolate-colored clays below Mount Vernon yielding fine impressions of plants, of which I made a small collection. These lie upon the freestone and underlie the Aquia Creek beds. I named them the Mount Vernon clays. On November 6 a much larger collection was made from the same locality. This entire region, including all the bluffs of the Potomac below Mount Vernon as far as Masons Neck, was further investigated during the autumn of 1892, the last excursion being made on the 18th of December. In the work I was voluntarily assisted by Mr. Victor Mason. The Mount Vernon clays were found in White House Bluff, and plants were collected from them there. They were traced up Doag Creek and as far west as the railroad near Pohick Creek.

Active operations were also carried on in the environs of Washington on both sides of the Potomac and Anacostia rivers. Owing to extensive excavations at nearly all points, the conditions were favorable for studying the relations of the several members of the formation, and making sections at points which were undergoing rapid change, so that most of them could never be seen again to the same advantage. I availed myself of these opportunities, visiting and taking careful notes on all the new exposures. The most important results were obtained in the northwest section of Washington City. One of the most instructive of these exposures was that on Ontario avenue, on the south side of Lanier Heights. At the west end the decomposed crystalline (micaceous schistose) rocks are seen underlying the white Rappahannock sands. The crystallines are strongly tilted to the east, and the sands lie on their inclined surface

and pass below the base of the section, having a thickness of about 20 feet. They contain clay lenses and nodules, but, as on the James River, the basal clays have disappeared. An excellent view of this exposure was taken while it was fresh. This is shown in Pl. LXXIV.

Views were also taken of the fine exposure on Kansas avenue near this same place and between the Adams Mill road and Ontario avenue. One of these is shown on Pl. LXXV. It was in these sands on this street that a fine silicified trunk was collected by Mr. Karl Woodward (son of Prof. R. S. Woodward), and presented to the National Museum, where it bears the museum No. 8603. It doubtless belongs to the genus Cupressinoxylon (Sequoia), to which Doctor Knowlton referred all the trunks examined by him, several of which were found in the city of Washington.

Views were also taken of the fine exposures on the east side of Sixteenth street through Meridian Hill. The contact with the crystalline rocks was not reached in the excavations here made, but the Potomac beds were well exposed. The cross-bedded white sands are beautifully shown, but these are overlain by more argillaceous, irregularly stratified beds that form the lowest part of the exposures near the top of the hill, the cross-bedded sands running under them on the southern slope. Four views were taken, but two of these are so nearly duplicates of the other two that they add little to them. The view shown in Pl. LXXVI was taken from the south side of Crescent street looking northeast, and is therefore panoramic or diagonal to the exposure. The view may be better understood by reference to the section (section 10) on page 386, of these same beds. It covers about 10 feet, beginning very close to the Columbia cap and a little below the point where the sands disappear beneath the roadbed, and ending some distance south of the point where the Potomac clays do the same. The few specimens of poorly preserved fossil plants were found in the freshly plowed roadbed opposite these exposures (see p. 385).

This work was resumed early in the spring of 1893, and on April 16, accompanied by Messrs. Victor Mason and William F. Willoughby, I discovered an important plant bed near Fairfax Seminary, in a gulch known as Chinkapin Hollow. It is a short distance south of the Leesburg pike, 2 miles northwest of Alexandria and $1\frac{1}{2}$ miles northeast of Fairfax Seminary.

The gulch or deep ravine, at the bottom of which there is running water, with a spring near the plant locality, makes southward. On the left or east bank there is a fine exposure consisting chiefly of Rappahannock sand, but with clay seams, and in one of these, a foot above the stream bed, fossil plants were found in abundance. There is also much lignite, and this extends below the bottom of the ravine. A short distance below the principal plant bed is a bluff of typical cross-bedded Rappahannock sand. Well up in this bluff, about 20 feet above the stream bed, is a thin vein of fine buff-colored clay containing abundant remains of coniferous twigs with small cones and male aments, seeds, etc. A bivalve shell was also found here. A rather large collection was made at both the horizons. These plants are fully treated in a later part of this paper (see pp. 509–515).

On May 14, assisted by Mr. William Hunter and Mr. Victor Mason, I made a much larger and better collection than any of the previous ones from the Mount Vernon clays, both at the original locality discovered by me on October 16, 1892, and also in White House Bluff, at a locality discovered on December 5, 1892.

Nearly the whole month of July was devoted to a critical reexamination by Professor Fontaine and myself of the Potomac beds of the District of Columbia, Maryland, and Virginia from Baltimore to Fredericksburg. We confirmed my previous observation that the conditions to the northwest and north of Washington closely approaches those of Virginia, the principal difference being that the Rappahannock sands are not lithified and are somewhat less feldspathic, being generally white and cross-bedded. But in passing eastward on the strike these sands are soon overlain by the dull-red clays characteristic of the Maryland exposures. This condition begins at Eckington, within the city, and is well shown in numerous cuttings on the Metropolitan branch of the Baltimore and Ohio Railroad, notably at Terra Cotta. Typical basal clays may be seen at Lamond, also on the railroad. The plant bed at the bottom of the new reservoir was found to be in lignitiferous clays of the same age underlying the sands, which here hold large quantities of silicified wood. At many points northeast of Washington the dull-red clays that overlie the white (here often yellowish and ferruginous) sands are in turn overlain by a

more indurated and ferruginous sand or sandstone with iron crusts and geodic lumps approaching bog ore. At some points, as, for example, in the region of Bladensburg, there seems to be an imperceptible transition from the basal clays to the ferruginous shales, which are finally overlain by purple clays, but it must be admitted that good exposures are rare. The lower sand member is often wanting in Maryland, and the dull-red clays often rest on the basal lilac clays. The sands do, however, appear in places, to some extent in the railroad cutting through the divide between the Potomac and Chesapeake drainages between Muirkirk and Contee, but especially near Savage in the Little Patuxent Valley. On the Patapsco close to the river at Relay there is a bed of typical arkose sand not distinguishable from that of the James River.

On July 20 we made a careful examination of the Federal Hill beds in Baltimore, and measured the section, working out as far as possible the homologies with the Virginia exposures and those in the District of Columbia.

A still further agreement in the conditions in both States is the occurrence of lignite beds near the base of the series. This is seen in Jessup's cut through the divide between the Patuxent and the Patapsco on the Baltimore and Ohio Railroad, and at many points near Hanover station, especially at the Reynolds mine a mile south of that point. The close resemblance between the indurated sands and ferruginous shales with casts and molds of stems and plants and the Rappahannock sandstones similarly affected seems to correlate these phases. About the only difference is the reddish color of the Maryland beds, due to the iron which colors nearly all the rocks of the Maryland Potomac.

The expedition was continued southward and the banks of the Potomac were thoroughly explored on both sides of the river. In Virginia the entire belt was restudied to the Rappahannock River. Perhaps the most important observation was that at many points below Mount Vernon, notably at Cockpit Point, the basal clays have a decidedly greenish color, so much so that they were at first thought to be glauconitic. Upon analysis, however, the green color was found to be due to chlorite, and this was doubtless derived from the serpentine and talcose schists that lie to the west of this region. These greenish clays, however, where long exposed to atmospheric conditions, change to a lively pink color. At

Cockpit Point, in rocks overlying these clays and representing the Rappahannock freestone, much more distinct plant impressions were found than had ever been seen elsewhere under the same conditions, and a considerable collection was made on July 27.

The kodak was in use during this entire expedition. The conditions, however, were not always favorable, and some of the views were not clear. A few of them are fairly representative and may be introduced here (see Pls. LXXVII, LXXVIII).

Two other excursions were made on August 5 and 8 to Gunstons Cove, Masons Neck, and White House Bluff, for the purpose of reexamining these exposures in the light of information gained since they were last seen, especially relative to the green basal clay which had so greatly puzzled me on previous occasions. It proved to be the same as at Cockpit Point. Specimens of the latter had been sent to Prof. J. S. Diller for analysis, and under date of November 28, 1893, he reported upon them as follows:

> To-day I examined carefully the greenish sand you gave me from "Cockpit Point, green basal clay from under plant bed, July 27, 1893." When put in water the sand becomes more clearly green. Under the microscope I found a very considerable amount of green mineral fragments. Some of these were clearly pleochroic and doubly refracting, like hornblende and chlorite. They were evidently not glauconite, which is not pleochroic and gives aggregate polarization and could be quite easily distinguished from such well-marked mineral fragments.
>
> There are plenty of these green particles of hornblende and chlorite, and it is to these that the specimen owes its color, chiefly if not wholly. There are a few grains which, on account of their opacity, could not be clearly determined, and it is possible that they are glauconite, but of this I could get no proof.
>
> I compared the above material with typical greensand of New Jersey, in which the glauconite is abundant and characteristic, but I could not find any grains in your specimen that gave the same results to optical tests that the glauconite of the greensand did.

The work on the Potomac was interrupted by an expedition to the Black Hills, but was resumed in October, and many other exposures were examined. It was continued on pleasant days during the open winter of 1893–94. On January 14, 1894, an excursion was made up Back Lick Run southwest of Alexandria, where some excellent exposures occur. Mr. Victor Mason accompanied me on this excursion and assisted me in taking a number of kodak views. The relations of the beds are nearly the same here as on Sixteenth street in Washington, except that the green chloritic

clays are present beneath the white cross-bedded sands. These relations are clearly seen in Pl. LXXIX.

In view of the excellent fresh exposure existing that season on Sixteenth street above Florida avenue, which as was expected, was soon after obscured and will never be presented again, I made a special effort to work out the relations of the beds, and on several occasions in May and June, 1894, I carefully measured the strata, recorded the results, and drew a diagrammatic section to scale, which, as typical of much of the Potomac formation, I consider worth introducing here. The strata consist of basal Potomac cross-bedded sands below, overlain by irregularly stratified clays that hold plants characteristic of the Rappahannock series. Upon these latter lies a very definite bed of stratified gravels and clays which may perhaps be referred to the Lafayette formation, and on the crest of the hill is a small cap of Columbia bowlder clay. The section was measured on the east side of the street, beginning about 200 feet north of Florida avenue and extending to the top of the hill, a distance of 660 feet. The beds all dip slightly to the north, and as a consequence the several formations appear to plunge into the hill and pass under the roadbed. This, as then graded, rose 33 feet in the 660 feet measured at the base, or one foot in 20. At the bottom of the section the basal sands occupy 360 feet, the clays 200 feet, and the gravel bed 100 feet. But the clays begin at a point 150 feet north of the origin of the sands, and are thus exposed for a distance of 310 feet, while the gravels begin 210 feet north of the origin of the sands, and are exposed for a distance of 450 feet. The sands have a maximum thickness of 20 feet, the clays of 10 feet, and the gravels of 20 feet. The cap of Columbia is 5 feet thick. At this maximum point the exposure measured 45 feet in thickness. The northward dip gives an additional 20 feet, making the section 65 feet. The clays overlap the sands a distance of 210 feet, and the gravels the clays 350 feet. The following is the section (compare Pl. LXXVI).

Description of the section shown in fig. 10.

		Feet.
1. Cross-bedded Rappahannock sands		25
2. Stratified clays (Rappahannock)		15
3. Lafayette (?):		
a Lower gravel bed	5	
b Clay and loam	10	
c Upper gravel bed	5	
Total		20
4. Columbia bowlder clay		5
Total exposure		65

The following literal extract from my notebook, written on the ground with the exposure before me, on the same days that it was measured, May 6 and June 3, 1894, contains a detailed description of the beds and will serve for all the exposures in that section and in great measure for the Lower Potomac beds generally:

On the east side of Sixteenth street the exposure begins about 200 feet north of Florida avenue. It is here 12 feet high and consists entirely of Rappahannock sand, loose, fine, white, with yellowish-brown ferruginous streaks, stratified in numerous somewhat lenticular layers, but generally horizontal, the layers themselves strongly cross-bedded, the lines of bedding more or less variable for each layer, usually dipping strongly northward, often at an angle of 45°. Sometimes they curve back and form a series of loops.

The exposure thickens gently northward, becoming 25 feet thick 150 feet from its point of origin. At this maximum point the clay bed begins at the top, thickens rapidly at the expense of the sand, becoming 15 feet thick where thickest. It is light ash colored, stratified, and cracks across the veins. The stratification is undulating. It passes under the roadbed 200 feet north of the point where the sand disappears. It also forms the roadbed, and it is this lowest visible horizon that yielded the only plants collected from this locality. Near the top for most of its length this bed becomes a very irregularly stratified sand, which is more or less black from the presence of limonite.

The Lafayette extends continuously from its point of origin, 60 feet north of that of the beds last described, to the end of the section, having a nearly uniform thickness of about 20 feet. For most of the distance this is divided into three clearly defined strata—a lower gravel bed of about 5 feet, a middle clay-loam bed of about 10 feet, and an upper gravel bed of about 5 feet. The lower gravel bed is more irregular than the upper, the stones vary more in size, some of them being large bowlders, and there is more clay and sand between them, the clay lumps being sometimes pink. The intermediate bed is clearly stratified, destitute of pebbles or cobbles, and varies in color from a bright pink to a dull yellow or dirt color. It has a very definite upper boundary. The upper gravel bed is a little thicker than the lower one. The pebbles are more worn, washed clean and often shining, the interstices between them filled with mostly red sand.

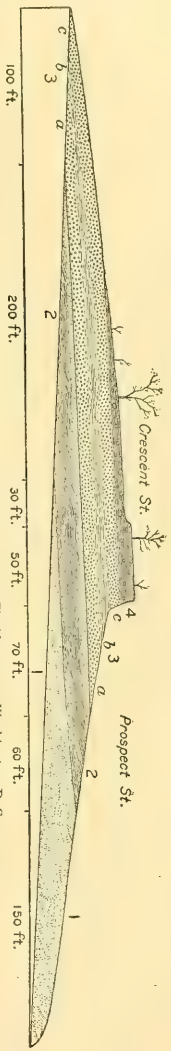

FIG. 10.—Potomac exposure on Sixteenth street above Florida avenue, Washington, D. C.

It is very possible that all except the Potomac beds in this section may belong to the Pleistocene formation (Columbia).

The specimens collected during the season of 1893, and other small collections previously made from Older Potomac beds, were sent to Professor Fontaine on October 28, 1893, but he could not determine them at the time on account of other work in hand, and they are treated in this paper for the first time. In his letter dated January 10, 1894, he remarked that in the collections from Cockpit Point "the grouping is decidedly the same as that found at Fredericksburg."

In the first biennial report of the Maryland State Weather Service, which was distributed at the beginning of 1894, its director, Prof. Wm. B. Clark, devotes a chapter to the geology of the State,[a] thus marking the beginning of his subsequent active studies in that line and foreshadowing the organization under his direction of the present State Geological Survey. He here treats "The Lower Cretaceous (Potomac)" (pp. 37–38) very briefly, and concludes with the following remark:

> The fossils found in the deposits, although not as numerous or distinctive as might be desired, yet indicate beyond doubt the Cretaceous age of the formation. They consist chiefly of the bones of dinosaurian reptiles and leaf impressions.

It was during the first half of 1894 that I prepared my paper on the Potomac formation for the Fifth Annual Report of the United States Geological Survey, and the manuscript and drawings were submitted for publication on June 26. This paper embodied the results of the special field investigations of the previous nine years, a brief account of which has been given here. It can not be called a final report, but must be regarded rather as a preliminary one. Nevertheless, I have not been able to prepare anything more extended, and it represents the state of our knowledge of the formation at that date. The paleontology was used to supplement and confirm the stratigraphical conclusions, but, in view of the recent appearance of Professor Fontaine's monograph of the flora, the only systematic matter introduced related to the florula obtained from the Mount Vernon clays, which was so different from the general flora that I considered it important to make it known. This paper was read in part before the Geological Society of Washington on March 28

[a] The Climatology and Physical Features of Maryland, First Biennial Report of the Maryland State Weather Service for the Years 1892 and 1893, by Wm. B. Clark, Director, Baltimore, 1894, pp. 29–44.

and May 23, 1894, and was fully discussed by all the geologists who had studied the formation.

Mr. W J McGee read a paper before the International Geological Congress, at its meeting in Washington in 1891, the publication of which was delayed until sometime in 1894,[a] in which the Potomac formation is treated among the rest that make up the geology of Washington. In this paper (p. 238) he extends the formation to include the later beds of New Jersey (Raritan formation) and the South (Tuscaloosa formation), but he does not indicate whether he considers these beds later in deposition than those of Virginia. In saying that Professor Fontaine regards the Potomac as "probably equivalent to the Cenomanian of Europe," the word "Cenomanian" is probably an error for Neocomian.

Field work in the Potomac of Maryland was actively prosecuted by Mr. Bibbins and myself until the end of July, 1894. There were several reports of finding impressions of ferns and other plants in the iron-ore region, especially on the Bannon estate at the Kilbern ore bank. One of these fern leaves had attracted special attention and was traced to persons in Towson, where it had been sent, but all efforts to find it failed. Mr. Bibbins followed up all these indications with great persistence, and at last, on July 17, he succeeded in finding a spot on the above-mentioned estate where plant impressions occur in the iron-ore beds. He immediately reported the fact to me, and in his letter, dated July 18, 1894, says:

> This ore is very different from any other brown ore I ever saw. It is raised either as ore or paint, and is obtained near the surface by "gouging." I secured a dozen of the lumps and upon breaking them open found that they were full of plant remains, and that some of the leaves were very perfectly preserved. Fern leaves were among the species found.

He sent me a few specimens, which I examined and reported on to him as follows, under date of July 20:

> I can identify at least one species, viz, *Cladophlebis acuta* Font., thus far only found in the Rappahannock series. I think you have also *Dryopteris fredericksburgense* Font., found in both the Rappahannock and the James River series, and also in the Kootanie of the West. We begin to know now where to look for plants in the iron-ore region; they are right among the ore. The little fragment I got at

[a] Geology of Washington and vicinity, by W J McGee, with the collaboration of G. H. Williams, Bailey Willis, and N. H. Darton: Compte-Rendu de la 5me Session du Congrès Géologique International, Washington 1891, Washington, 1893, pp. 219–251.

the Reynolds pit doubtless occupies the same position, only in the steel ore, and this ought to be followed up, its exact horizon found, and further collections made.

Everything seems to confirm my suspicion that there is no great difference between the brown ore and the white ore from a geological point of view. I am satisfied now that there is really no such thing as an "iron-ore series," stratigraphically distinct from the basal Potomac of Virginia, and I am glad I spoke with so much reservation on this point in my paper.

This was the first light that had been shed on the true age of the iron-ore beds. It showed that they must be correlated with the Older Potomac of Virginia and with the Rappahannock series.

The work was interrupted in midsummer by my absence of two months in Europe, the object of which was twofold: First, to study the Wealden of England and Lower Cretaceous of Europe generally, and especially of Italy and Portugal; and second, to see all the cycad trunks possible in European museums for comparison with those of America. In both of these objects I was measurably successful, and returned on the first of October better prepared to resume the study of the Potomac formation. The results of my European studies were published in a paper, to which further reference will presently be made (see p. 393).

Early in the spring of 1895 I made a reconnaissance in the South, most of which was devoted to a study of the Tuscaloosa formation and will be considered in a later paper, but on my return I stopped at Fayetteville, N. C., and descended the Cape Fear River from that place to the mouth of Harrisons Creek, 32 miles below, devoting two days to the region and studying the banks at numerous points. These furnish a section through a great thickness of the Lower Cretaceous, but it is difficult to correlate the beds with those farther north. The higher beds farthest down the river yield imperfect specimens of dicotyledonous leaves having affinities with those of the Newer Potomac and are doubtless of that age, but those at Lafayette, and for 10 or perhaps 20 miles below, though apparently barren, closely resemble Older Potomac strata, but are transgressed by marine deposits which occupy the top of the bluffs nearly the whole distance. At Fayetteville the Potomac beds rise about 40 feet above the river. At the water's edge there was seen a bed of greenish clays weathering red, in close imitation of those of the Potomac at Cockpit Point. These had a thickness of 4 feet. The next 4 feet consisted of coarse sand holding small vein-quartz pebbles and a few clay

nodules. Next came a bed of dark-greenish clays 25 feet thick. There was a stratified layer above this some 3 feet thick, and the uppermost bed, 6 or 7 feet thick, consisted of coarse, gray or white arkose sand or gravel, scarcely differing from the one below, but holding silicified wood. These beds of arkose seemed to represent the Rappahannock freestone and the interstratified clays to correspond to the clay lenses in the James River deposits.

I stopped at Weldon on April 6 and reexamined the exposure at the north end of the railroad bridge, seen by our party in 1885. It was in better condition and some 30 feet of the sands were visible. The lower 20 feet were especially clear and were cross-bedded. The upper 10 feet were more regularly stratified and striped with shades of brown, the sand finer and not cross-bedded. No clay inclusions were seen. It still remains problematical.

This place was again visited by me in June of the same year, in company with Prof. J. A. Holmes, State geologist of North Carolina, and Professor Fontaine, but during the interval since my visit on April 6 there had been floods and the fine bank of sand had been washed and undermined, covering all the lower part of the exposure with talus. The same party made a somewhat thorough examination of a large area in that State coastward of the Triassic outcrops, in the hope of finding the Older Potomac. There seems no doubt of its occurrence near Moncure (Haywood). Rather typical arkose was found there. We traveled from Sanford to Fayetteville in two hand cars, kindly lent us by the railroad company, which enabled us to study the geology to good advantage. All the upper beds are of Tuscaloosa age, but in the bed of the lower Little River, at the railroad bridge, just above the water and 20 feet below the tracks, there occur massive, green or bluish sandy clays, which were believed to represent the Older Potomac. These rest on the crystalline rocks. At Old Manchester, below an abandoned factory, the river banks are 50 feet high, most of which consist of this clay, which weathers red and purple. The upper 12 feet seem to be Tuscaloosa resting on this clay.

The party descended the Cape Fear from Fayetteville to Wilmington, stopping and examining the bluffs at numerous points. The section seems to be complete from the Older Potomac through the marine Cretaceous (Matawan), and the Later Tertiary beds overlie this last.

We saw no reason to question the Older Potomac age of the lower beds at Fayetteville, as described above, and it now seems certain that such beds occur at many points in that general region, although, unfortunately, no paleontological evidence has yet been found.

Several papers relating in one way or another to the Older Potomac appeared during the year 1895.

In a paper in Science[a] I gave the results of my examination at Aix and Fonscolombe in Provence, France, in August, 1894, of the material collected in Portugal by M. Paul Choffat, and sent to the Marquis Saporta at Aix for determination. It contained archaic dicotyledons from the Lower Cretaceous, about which the Marquis had written me and which I greatly desired to see. I found his work nearly ready for distribution and I received it soon after my return to America. This paper is practically a review of that work, with special reference to the American floras that most closely correspond to those of Portugal.

In the same number of Science (p. 362) there is an unsigned note, which is known to have been contributed by Mr. F. A. Lucas, on the vertebrate remains that had recently been discovered by Mr. Bibbins in the Potomac formation of Maryland. These represented the genera Allosaurus, Pleurocœlus, and Priconodon, and also contained a tooth of *Astrodon Johnstoni* Leidy.

Doctor Knowlton contributed an article on the primitive dicotyledons of the Potomac[b] to the Popular Science News for April and May, 1895, calculated to popularize this important branch of the subject.

Mr. Bibbins's paper[c] in the Johns Hopkins University Circular, No. 121, gives a clear summing up of his studies in the formation.

Mr. Benjamin Smith Lyman[d] reported probable Older Potomac beds in Pennsylvania, on Neshaminy Creek, near the mouth of Mill Creek, in the southern edge of Northampton Township, and at Sunny Hill schoolhouse, near the mouth of Core Creek, in Middletown Township, thus confirming the observations of Mr. McGee, as well as those of Mr.

[a] The Mesozoic flora of Portugal compared with that of the United States, by Lester F. Ward: Science, n. s., Vol. I, March 29, 1895, pp. 337–346.

[b] The oldest dicotyledons, by F. H. Knowlton: Popular Science News, Vol. XXIX, New York, April, 1895, pp. 49–51; May, 1895, pp. 66–68, illustrated by 20 text figures.

[c] Notes on the paleontology of the Potomac formation, by Arthur Bibbins: Johns Hopkins University Circulars, Vol. XV, No. 121, Baltimore, October, 1895, pp. 17–20, one plate.

[d] Report on the New Red of Bucks and Montgomery Counties, by Benjamin Smith Lyman: Pennsylvania State Geological Summary Final Report, Vol. III, Part II, 1895, pp. 2634–2635.

David White and myself, that the Older Potomac actually occurs in Pennsylvania.

The year 1896 was the most prolific thus far in the public discussion of the nature and age of the Potomac formation. The Fifteenth Annual Report of the United States Geological Survey contains my paper on the Potomac formation,[a] completed and submitted in June, 1894. It was soon followed by the Sixteenth Annual Report, Part I of which contains Professor Marsh's elaborate memoir on the dinosaurs of North America,[b] in which the Potomac vertebrates are described and figured; and my paper[c] comparing the Lower Cretaceous of America, and especially the Potomac formation, with the Wealden of England, the Scaly Clays of Italy, and the Mesozoic plant-bearing deposits of Portugal. This volume was in the hands of the geologists in October. Professor Fontaine's long-delayed work on the stratigraphical relations of the Potomac formation[d] (see p. 358) appeared in December. It had undergone extensive revision at Professor Fontaine's hands since the manuscript was originally prepared in 1883, being designed as a geological introduction to his monograph of the flora of the Potomac formation, but not used as such. The geological map was prepared under my supervision and extends from Petersburg to Baltimore. In it no attempt is made to subdivide the formation.

These works, in which the age of the Potomac formation was freely discussed, with wide differences of opinion, led to a controversy in the form of short articles by geologists who had paid more or less attention to the subject. The unqualified assertion of Professor Marsh that the Maryland dinosaur bed was Jurassic, and his final position that the entire Potomac formation, including the Amboy clays and the beds on Long Island, Block Island,[e] Marthas Vineyard, etc., which I had called the Island series, all belonged to that age, attracted special attention.

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[a] The Potomac formation, by Lester F. Ward: Fifteenth Ann. Rep. U. S. Geol. Survey, 1895, pp. 307–397, pl. ii-iv.

[b] The dinosaurs of North America, by Othniel Charles Marsh: Sixteenth Ann. Rep. U. S. Geol. Survey, Pt. I, 1896, pp. 133–414, pl. ii–lxxxv.

[c] Some analogies in the Lower Cretaceous of Europe and America, by Lester F. Ward: Op. cit., pp. 463–542, pl. xcvii–cvii.

[d] The Potomac formation in Virginia, by William Morris Fontaine: Bull. U. S. Geol. Survey No. 145, 1896, 149 pp., map.

[e] The geology of Block Island, by O. C. Marsh: Am. Jour. Sci., 4th ser., Vol. II, October, 1896, pp. 295–298; November, 1896, pp. 375–377. The Jurassic formation on the Atlantic coast: Ibid., December, 1896, pp. 433–447.

The first of these papers was promptly replied to by Dr. Arthur Hollick,[a] who was probably the best informed person as to the age of the Block Island beds. In view of my prolonged studies of the whole series of beds of which those of Block Island constituted only one link in the chain from Staten Island to Nantucket, the age of which I had so closely worked down from the vegetable remains, I also felt called upon to reply, and this I did in November,[b] before the appearance of the third and more elaborate paper of Professor Marsh. I did not care to discuss the age of the beds in Maryland from which the only vertebrate remains had been obtained, and confined myself to showing that the Block Island deposits, which he classed along with these as Jurassic, were much higher in the series.

Mr. Gilbert, professing no expert knowledge of paleontology, wrote wholly in the interest of method,[c] and said:

> The number of persons to whom the local question of correlation is important may not be large, but the whole body of geologists and paleontologists are concerned with the methods and principles of correlation, and an excellent opportunity seems to be here afforded for the comparison of vertebrate with botanic evidence. I therefore write to express the hope that when Prof. Marsh continues the subject, as he has promised to do, he set forth the grounds for the conclusion he has announced with so much confidence. His article states, in effect, that through a comparison of vertebrates from the Potomac formation with vertebrates from other formations he has inferred the Jurassic age of the Potomac; but he gives no hint of the character of his evidence or the course of his reasoning, so that the conclusion has at present only the authority of his statement, without opportunity for verification.

Mr. Hill[d] defended the Cretaceous age of the Wealden, to which Professor Marsh admitted that the Potomac might belong. It is easy to see how this was vital to Mr. Hill, because it would certainly place the Comanche series of Texas, which is admitted to go down even lower than the oldest Potomac, in the Jurassic, and Mr. Hill, as we have seen (p. 341), had long abandoned that position.

Mr. Marcou's contribution[e] ought scarcely to be included in this series, as the Potomac is not mentioned, and it is devoted to sustaining

[a] The geology of Block Island, by Arthur Hollick: Science, N. S., Vol. IV, October 16, 1896, pp. 571–572.
[b] Age of the Island series: Science, n. s., Vol. IV, November 20, 1896, pp. 757–760.
[c] Age of the Potomac formation, by G. K. Gilbert: Ibid., December 11, 1896, pp. 875–877.
[d] A question of classification, by Robert T. Hill: Ibid., December 18, 1896, pp 918–920.
[e] The Jurassic Wealden (Tithonian) of England, by Jules Marcou: Ibid., Vol. V, January 22, 1897, pp. 149–152.

Professor Marsh's general claim that the Wealden should be referred to down the Jurassic.

In order still further to emphasize the wide difference between the Older and Newer Potomac, and also to give the views of Professor Fontaine, who had most fully studied the former, and of Doctor Newberry, who was at the time of his death the first authority on the latter, I made a second contribution[a] in the spring of 1897, quoting somewhat extensively from those authors, and endeavoring to show that Doctor Newberry placed the Amboy clays somewhat too high, while Professor Marsh placed them much too low and confounded them with the Older Potomac.

Professor Clark and Mr. Bibbins published in August, 1897,[b] a somewhat full account of the results at which they had arrived in their study and preliminary survey of the Potomac formation in Maryland. They admit the great difference between the age of the lower and the upper beds, and sustain the view which I maintained in my paper on the Potomac formation in 1895, that it consists of a series of beds dipping coastward and beveled on the surface, so that in crossing the belt from northwest to southeast one rises in the geological scale from the lowest to the highest beds; in other words, that the Potomac formation is not a "trough," as was formerly supposed, but an integral part of the sedimentary beds that make up the coastal plain. They did not, however, accept the nomenclature that I proposed, but adopted an entirely different one, making four instead of six subdivisions, which in ascending order are as follows: Patuxent, Arundel, Patapsco, Raritan. On page 481 they say:

> It is the conclusion of the authors, founded upon a detailed stratigraphic study of the Potomac group, that all the beds which have afforded dicotyledonous types of plant life are above those which have yielded the vertebrate remains, and, moreover, that a marked unconformity exists between the two series of deposits. The evidence for this conclusion will be brought out in the succeeding pages.

This was an inference only, and has been disproved by the study of the plants that had been already collected. The Patuxent formation is described as follows:

> The deposits of the Patuxent formation consist mainly of sand, at times quite pure and gritty, but generally containing a considerable amount of kaolinized feld-

[a] Professor Fontaine and Doctor Newberry on the age of the Potomac formation: Ibid., March 12, 1897, pp. 411–423.

[b] The stratigraphy of the Potomac group in Maryland, by Wm. Bullock Clark and Arthur Bibbins: Journ. Geol., Vol. V, No. 5, July–August, 1897, pp. 479–506.

spar, producing a clearly defined arkose. Clay balls are at times distributed in considerable numbers through the arenaceous beds, which in places contain lenses of gravel, sometimes with cobble stones. Frequently the sands pass over into sandy clays and these in turn into more highly argillaceous materials which are commonly of light color, but at times become lead-colored, brown, or red, and not unlike the variegated clays of the Patapsco formation. Those arenaceous materials which lie adjacent to ferruginous clays are not infrequently indurated by hydrous oxides of iron, forming ferruginous sandstone. The more arenaceous deposits are commonly cross-bedded, and the whole formation gives evidence of rapid deposition. (See pp. 481–482.)

This description would answer well for the James River and Rappahannock series by omitting the reference to the coloring effects of iron. It leaves out, however, the clay lenses and lignite beds yielding fossil plants that occur in the regular sedimentary beds in both the James River and the Fredericksburg regions. They describe the Arundel formation as follows:

The deposits consist of a series of large and small lenses of iron ore-bearing clays which occupy ancient depressions in the surface of the Patuxent formation. These clays as most typically developed ("blue charcoal clays" of the miners) are drab colored, tough, and frequently highly carbonaceous, lignitized trunks of trees and limbs lying horizontally strongly compressed and frequently charged with or inclosed by carbonate and sulphide of iron. Sometimes these trunks are encountered in an upright position, with their larger roots still intact. Scattered through the dark clays are vast quantities of nodules of iron carbonate, at times reaching many tons in weight, and known to the miners as "white ore," "hone ore," or "steel ore." In the upper portions of the formation which have been exposed to atmospheric influences the carbonate ores have sometimes to considerable depth changed to hydrous oxides of iron, which the miners recognize under the name of "brown" or "red" ore. Under these conditions also the originally drab-colored clays containing the carbonate ores have suffered a like chemical change, resulting in red or variegated clays. Where these clays chance to contain but little lignite the iron ore may consist almost entirely of these oxides.

Here again the presence and peculiar influence of large quantities of iron obscure the resemblance of these beds to the clay lenses and lignite beds of the Older Potomac in Virginia, with which they are otherwise identical both in character and in mode of occurrence. But iron is not wholly wanting in the same clay deposits in Virginia. Professor Fontaine has reported its occurrence on Powells Run and near Cockpit Point, and I have seen a bed near Bush Hill, not far from Alexandria, where the

owner of the land contemplated working the swamp for nuggets of ore. If the Potomac River had not cut away the deposits for the space of 10 or 15 miles it would probably have been possible to follow the transition from the light-colored indurated sands to the ferruginous sands of the same age and type without any abrupt change from the one to the other. And now that the Arundel has yielded a considerable flora consisting almost wholly of Rappahannock species, there is no longer any question of the practical identity in age of the Virginia and Maryland beds. The Patuxent represents the regularly stratified sands and clays of the Older Potomac, and the Arundel consists of the lignite beds that are included in the latter.

The Patapsco formation is thus defined:

> The deposits of the Patapsco formation consist chiefly of highly colored and variegated clays which grade over into lighter colored sands and clays, while sandy lenses of coarser materials are sometimes interstratified, which are occasionally indurated and at times form "pipe ore." The clays are in places dark colored, massive, and more or less lignitic. At times they are laminated ("slaty") and bear large numbers of leaf impressions. Fossiliferous flakes and nodules of "white" and "red ore" also occasionally occur. The sands sometimes contain much decomposed feldspar, and rounded lumps of clay are also found. The sands are frequently cross-bedded and give evidence of rapid deposition. Workable beds of "paint rock," as the highly ferruginous clays are termed, are found at many points, usually near the base of the formation.

It is more difficult to correlate this with Virginia beds than it is to correlate the two formations already considered. I was of course wrong in supposing that the iron-ore clays extended to the top of these beds, but I was influenced by the view so long held by nearly everybody that the Maryland beds in general constituted an "upper clay member" higher than the "lower sandstone member" of Virginia. I had, however, discovered that the Older Potomac "flanks it for its whole length" through the State of Maryland. I stated positively that the white ore, or steel ore, was found in the Rappahannock series, but I supposed that the brown ore was higher. As no plants except cycads had been found in either at that time, the age could not be determined by paleontological evidence.

It now appears from Professor Fontaine's report on the fossil plants, many of which were found in beds referred to the Patapsco, that there is scarcely any difference between the flora of the Patapsco and that of the Arundel, and that both belong to the Rappahannock

series. Indeed, Professor Fontaine now places the Federal Hill beds in Baltimore, formerly regarded as representing the Brooke series, in the Rappahannock, and finds no true Brooke flora anywhere in Maryland except at Rosiers Bluff, above Fort Foote, on the Potomac, which seems to be a simple continuation of the beds at White House Bluff, across the river.

The Patapsco is therefore not a paleontological division, and the number of plant-bearing beds of which the position is regarded as doubtful shows that the authors are far from knowing the characteristic marks by which it can be recognized with certainty. After visiting nearly all their sections I have arrived at the conclusion that none such exist.

The Raritan formation is synonymous with what I called the Albirupean of Uhler. I understood him to limit it to the upper clays and sands yielding a chiefly dicotyledonous flora. Professor Uhler has since so greatly expanded his conception of the Albirupean that it is difficult to retain his name, and as the name Raritan was very early applied to most of the clays of New Jersey, that name may be regarded as having priority over all other names that admit of use as designations for a heterogeneous formation.

Influenced by "the distinguished authority of Professor Marsh," the authors of this paper provisionally refer the Patuxent and Arundel formations to the Jurassic, and in their comparative taxonomic table, on page 505, they place the former of these below any of the Virginia beds, all of which they include in the Cretaceous.

In Science of August 5, 1898, and in the American Journal of Science for August of that year, Professor Marsh published a "Supplement" to his paper already considered on The Jurassic Formation on the Atlantic Coast, in which he replied to the various articles that had appeared criticising his position. He had, however, discovered no further evidence. He was then in possession of many trunks of cycads from the Black Hills, and he also referred the beds from which they came to the Jurassic, although they were found in the sandstones of the "rim" which had all along been called "Dakota group," and so regarded even by himself in various sections that he had made. I had found a flora below the cycad horizon that proved the whole to be Lower Cretaceous. But Professor Marsh had also received specimens of cycads from the

Freezeout Hills of Wyoming, and in a "Postscript" to this paper he considers these in the same connection and correctly says that they came from the Jurassic. This he claimed to sustain his view of the Jurassic age of the cycads of the Black Hills and of the Potomac. I came into possession a few months later of a much larger collection of these Jurassic cycads and fully described and illustrated them. It turned out that they all belonged to a different genus (Cycadella) from the rest, which seems to be characteristic of the Jurassic trunks.

It remains to mention the second paper of Messrs. Clark and Bibbins, read before the Geological Society of America on December 31, 1901,[a] in which they again go over the same ground in much the same way, but do not greatly increase our knowledge of the formation and do not materially change the conclusions reached in the paper last treated.

Before this paper was read Professor Fontaine had sufficiently advanced with his work of determining the plants to make it certain that there was no part of the Potomac of Maryland that does not yield dicotyledonous plants. The statements made in this paper relative to the flora do not seem to be based upon data obtained by consultation with him, but are practically repetitions of the erroneous statements made in the previous paper. For example, after stating (p. 192) that "the flora of the Patuxent formation includes equisetæ, ferns, cycads, conifers, monocotyledons, and a very few archaic dicotyledons, the coniferous and cycadean element being particularly strong," they say (p. 195) that "the flora of the Arundel formation includes algæ, fungi, lycopods, ferns, cycads (apparently fronds only), many conifers and monocotyledons, as well as a considerable showing of dicotyledons, which, though not specially advanced in type, are far beyond those of the Patuxent formation in grade as well as in variety and numbers. There is therefore a well-defined contrast between the dicotyledonous elements of these two formations." These statements are certainly premature and seem to be purely theoretical, based on the assumption of the greater age of the Patuxent, which is not borne out by its meager flora. So far as the trunks of cycads are concerned, they occur, accord-

[a] Geology of the Potomac group in the middle Atlantic slope, by W. B. Clark and A. Bibbins: Bull. Geol. Soc. America, Vol. XIII, July 29, 1902, pp. 187–214, pl. xxii–xxviii.

ing to Mr. Bibbins's statements in his contribution to the present paper, quite as frequently in the Patapsco formation as in the Patuxent.

In discussing the age of the Potomac deposits the authors say:

There has been much discussion as to the age of the Potomac group. Most geologists, particularly those who have studied the floras, have believed the entire group to be of Cretaceous age, while a few investigators, notably the late Professor Marsh, of Yale University, have regarded it of Jurassic age. The authors of this paper in an earlier publication pointed out this difference of view, and clearly showed that the dicotyledonous floras were practically confined to the two upper formations, while the dinosaurs on which Professor Marsh based the Jurassic age of the Potomac group were found in the Arundel formation. As the result of these observations, and without attempting to decide finally regarding the paleontologic evidence, they placed the two lower formations of the Potomac group questionably in the Jurassic. Since the publication of the above paper the authors have made a very exhaustive examination of the several formations and collected large numbers of animal and plant remains. As the result of this work a considerable dicotyledonous flora has been found to exist in the Arundel, although of somewhat primitive type. At the same time a single dinosaurian bone, somewhat waterworn, and possibly redeposited from the Arundel, has been found in the Patapsco, although its fragmentary character renders it impossible to determine its systematic relations. The results of these observations, together with the discovery by the late Professor Cope of a plesiosaur in the Raritan formation of New Jersey and of a dinosaurian limb bone by Woolman in the Matawan formation of the same State, although not definitely settling the age of the deposits, cast further doubts on the Jurassic affinities of the Arundel and at the same time of the underlying formation—the Patuxent.

The question as to the age of the Potomac group is therefore narrowed down to two propositions:

First. Is the Arundel dinosaurian fauna conclusive evidence of the Jurassic age of that formation, and therefore of the subjacent Patuxent? No less an authority than Professor Marsh, after a study of its dinosaurian fauna, unquestionably refers the Potomac group to the Jurassic, although at the time not cognizant of the complexity of its deposits. He regarded the Potomac as a single formation, as has been the case with many other geologists. In his view regarding the Jurassic age of the Potomac, Professor Marsh has been supported by a few others, mostly among English geologists, since the question here presented is recognized to involve the age of the Wealden as well. Professor Marsh lays much stress on the equivalence of the Potomac with deposits which he has regarded as Jurassic in the Rocky Mountain district, but some doubts have been expressed by others whether these deposits may not be younger. It seems to the authors that further study by vertebrate paleontologists is required before these questions can be settled and the Jurassic age even of the two lower formations of the Potomac group can be acepted on the evidence of the fossil vertebrates.

Second. Are the floras of the Arundel and Patuxent formations, with their primitive dicotyledonous types, of necessity Cretaceous? There is apparently no question regarding the Cretaceous age of the Raritan and Patapsco formations, the uppermost beds of the Raritan even containing floras that have been regarded by Professor Ward as middle Cretaceous. The paleobotanists who have studied the floras of the earlier formations admit that there are many forms which show Jurassic affinities. Professor Fontaine, in his study of these floras, states that there was an "overwhelming percentage of Jurassic types," but unhesitatingly refers the Potomac flora as a whole to the Cretaceous, correlating the deposits with the Cretaceous beds of England. This view is held by nearly all paleobotanists who regard the presence of dicotyledons, although of primitive types, as unquestioned evidence of the Cretaceous age of the Arundel and Patuxent formations. Further investigations of these floras may, to be sure, lead to other conclusions, but large collections have already been made, and the paleobotanists who have studied them have registered their decision regarding the Cretaceous age of the deposits in no uncertain way.

From our present knowledge of the floras and faunas, it is apparent that there is considerable disparity between the evidence afforded by vertebrate paleontology and by paleobotany. At least such is the case if equal consideration is given the conclusions of each group of investigators. It seems essential, however, to suspend final decision of these questions until more exhaustive investigation of the faunas and floras has been made throughout the entire coastal region. The authors therefore temporarily place the boundary line between the Jurassic and Cretaceous at the base of the Patapsco formation, but with the feeling that much doubt exists regarding it, and that the question is far from settled (pp. 212–214).

The facts here stated would seem sufficient to negative the conclusion drawn. The authors do not say that by Jurassic they mean beds of Wealden age, and we are to infer that they regard the Patuxent and Arundel formations as older than the Wealden of England and the Continent and as near the age of the Coral Rag, the Purbeck, or the Kimmeridge. That dinosaurs and other saurians are found in the Raritan, and even in the Matawan, effectually disposes of the claim formerly made that these types absolutely demonstrate the Jurassic age of any bed yielding them, and distinctively Jurassic species of saurians have not as yet been found in the Older Potomac beds. The occurrence of plants of "Jurassic affinities" does not prove their Jurassic age. It is but natural that the luxuriant Jurassic flora, such as that of Oroville, Cal., and of the Buck Mountain district in Oregon, should persist to some extent through the Lower Cretaceous. In both the flora and fauna the Lower Cretaceous forms, while having "Jurassic

affinities," are greatly modified. A casual comparison of a true Jurassic flora with the Potomac flora shows how profound the modification has been. The Shasta and Kootanie floras show an even more marked Jurassic facies than that of the Potomac, and yet the former of these is proved to be Cretaceous by its fauna, which is abundant, while no one has ever thought of referring the Kootanie to the Jurassic. It is even doubtful whether the oldest Potomac beds are as early as the Wealden. The Wealden of Europe has yielded a large flora, both in England and on the Continent, and yet there has never been found in it anywhere a single even archaic dicotyledonous plant. The evidence of the Cretaceous age for the entire Potomac formation would therefore seem to be conclusive.

That the Aquia Creek series, or Brooke formation, in Virginia, is largely made up of the materials of the older beds eroded out of them and redeposited has been held by Professor Fontaine, and was clearly set forth in my paper on the Potomac formation (p. 326). If the Patapsco and Brooke formations are the same, as there is every reason to believe, the former should have been formed in the same way, and that this was the case is clearly shown in the paper now under consideration. The excellent discussion (pp. 482–483) of the origin of the Arundel clays applies equally to the clay lenses of the James River and Rappahannock series, which are the true homologue in Virginia of the Arundel formation in Maryland. The latter also often forms the base of the Potomac.

Returning from this survey of the literature to a consideration of the work of collecting and determining the plants of the Potomac formation we have to record that on December 11, 1897, all the undetermined Potomac material (exclusive of cycads) that had resulted from the field explorations of several years was sent to Professor Fontaine for elaboration, with a view to publication in the series of papers that I was already planning on the Status of the Mesozoic Floras of the United States, but owing to the large amount of work that he had to do on the Triassic and Jurassic floras for the first of these papers slow progress had been made with the Potomac material. On October 8, 1900, a short time before my return from Europe, Prof. W. B. Clark wrote me with regard to the elaboration of the large collections that had then been made, chiefly by Mr. Bibbins, of fossil plants from the Potomac of Maryland. As these collections were much more extensive than those made

by myself and still in Professor Fontaine's hands, I considered it highly desirable to have them all brought together and treated in a single general report. I therefore recommended to the Director that the Maryland State Survey be permitted to use the electroplates of that part of my paper relating to the Maryland plants, on condition that the collections belonging to the State or available for its use be sent to Professor Fontaine for elaboration along with those already in his hands. The Director approved the plan and the collections were all shipped direct to the University of Virginia early in February, 1901.

In my correspondence with Professor Clark, and in several interviews during the early part of 1901, the question of nomenclature was freely discussed. It was admitted on my part that the name "Aquia Creek" was published by him a few months earlier than by me and must apply to the Eocene beds if used at all, though it is only a portion of Mr. Darton's Pamunkey. For the Potomac beds, so called by me, Professor Fontaine's term "Brooke" must be retained. It was also virtually admitted by Professor Clark, after personally examining the Virginia beds, that the Patuxent and Arundel were practically of the same age as the James River and Rappahannock, which I agreed with Professor Fontaine in regarding as a geographical rather than a stratigraphical distinction. It had already been conceded by me that my Iron Ore series, which was founded on stratigraphical evidence before any fossil plants had been found in it, included part of the Rappahannock beds and also the purple clays, and was therefore no longer tenable and must be abandoned as a geological designation. As this and the Brooke beds do not contain the same species of fossil plants, or only a few identical species, although they must have been to some extent synchronous, there seems to be no objection to the use of the term Patapsco for all the beds in Maryland between the iron ores and the Raritan.

The terms Patuxent, Arundel, and Patapsco, however, must be regarded as merely local synonyms and can not be applied to beds outside of Maryland. The older terms, James River, Rappahannock, and Brooke, of Professor Fontaine and myself are the true ones for the Older Potomac and may be used wherever that formation exists, as well in Maryland as in Virginia, and also in North Carolina, Delaware, and Pennsylvania.

THE MARYLAND CYCADS.

The important rôle that the silicified trunks of Bennettitaceæ, popularly known as "cycads," have played in the history of the Potomac flora in Maryland justifies and almost requires the special and separate treatment of these. In the above historical review I have, therefore, contented myself with recording the earlier discoveries of these trunks as a necessary part of the history of the formation, and have left for such special treatment the more recent operations and renewed activity in this line.

Nearly twenty years had elapsed since any special attention had been paid to the occurrence of cycads in the iron-ore beds of Maryland, when, in the autumn of 1893, Mr. W J McGee learned that Mr. Arthur Bibbins, of the Woman's College of Baltimore, had obtained some additional specimens and wrote to him concerning them. Mr. Bibbins, in his reply, dated October 14, said:

> * * * The fragments of Tysonia in our possession were purchased from the owners of the estates on which they were found by President John F. Goucher. * * * I have made thorough search for additional specimens, but thus far without success. Those occurring in the Baltimore region appear to be about all called in. None of the fragments were in place, and it can not be said with certainty that they are from the Potomac beds. Such, however, appears extremely probable from their position.

I wrote to Doctor Goucher to know whether the Woman's College would like to exchange any of these cycads for other museum specimens. Doctor Goucher was absent at the time, but there was some correspondence between Mr. Bibbins and Doctor Knowlton relative to cutting sections of the cycads, in which I also took part. Mr. Bibbins continued his search for the trunks among the people living in the region where they were found and succeeded in obtaining a number of others that had been picked up by miners and farmers on their land. The following item found its way into the Washington Post of January 9, 1894:

> Several fine specimens of fossils were found near Laurel last week by a geologist from the Woman's College, of Baltimore city. It is said the specimens belong to a species of the palm tree which existed in this country thousands of years ago.

I sent the clipping to Mr. Bibbins and offered to assist him in the prosecution of his work, especially wishing to ascertain the exact strati-

graphical position of the cycad-bearing beds. On February 6 I visited the Woman's College, had a conference with Doctor Goucher and Mr. Bibbins, examined the newly discovered trunks, and arranged to have the whole collection lent to the National Museum, where I could study it advantageously. It was also decided that I should accompany Mr. Bibbins to the localities where the specimens were obtained for the purpose of determining as nearly as possible their stratigraphical position in the beds. A provisional agreement was arrived at as to the types to be deposited in the National Museum in case the collection was elaborated there.

In March a thorough survey of the cycad field as known to Mr. Bibbins was made under his guidance. We visited all the localities at which the trunks known at that time had been collected. They had all been obtained from the inhabitants, who had picked them up on their land, but many of these persons could not give very precise information with regard to the original localities. In two cases the stratum in which the trunk was embedded when found was known, and in one of these it had been seen projecting from a cliff for many years before it finally weathered out and rolled down to the bottom of the gulch, which was only a short time before Mr. Bibbins obtained it, and Mr. Frederick Link, who picked it up and took it to his house, was able to put his hand on the depression, still visible in the cliff, where the specimen had lain. In May, 1895, I visited this place in company with Mr. Bibbins and Mr. Link, who had watched it so long and after it dropped out of the cliff rescued it from the gulch and took it to his house. It is therefore known as the Link cycad, and is figured on Pl. XC. The specimen, which we had brought with us, was restored to its original position and two photographic views were taken of the gulch and cliff, showing the cycad (see Pl. LXXXVIII.

This was the only absolutely conclusive evidence that had yet been obtained of the stratigraphic position of one of the trunks, but the very large number of trunks, more than one hundred now known, that have been found in the region leaves no room for reasonable doubt as to the true position of the cycad horizon. This will be considered later. It need only be stated now, as I had fully expected from a consideration of the conditions of silicification in general, that they did not come out of

clay beds, but always out of a more or less sandy material, usually from sand beds or beds of ferruginous arenaceous shale or lithified sand.

The entire collection of cycads in the possession of the Woman's College was shipped to the National Museum in April, 1894, and work was begun on them soon after.

Preparatory to my general studies in the cycads of the United States I prepared during the early part of 1894 a revision of the genus Cycadeoidea, to which the American forms thus far found all belonged.[a] This paper went to press before I felt authorized to make any statement of Mr. Bibbins's discoveries, and I could only mention those of Tyson and give the synonymy of the one species thus far named and called *Tysonia marylandica* by Fontaine, which becomes *Cycadeoidea marylandica* in the revision of Capellini and Solms-Laubach.

In July, 1894, I commenced to work in earnest on the Maryland cycads, describing the material. Photographs were made and sections cut. Several of the smaller trunks were cut through the center and the fresh faces polished. This part of the work was directed by Dr. F. H. Knowlton.

Mr. Bibbins's method of collecting the cycads, as has been seen, was unique and might be regarded by some as unscientific; but it was effective. I was much struck with his method as peculiarly adapted to such a case, and I regarded it as from this point of view eminently scientific. It was to make this method known and to give a brief historical account of the discovery of cycads in the Maryland beds that I prepared a paper[b] on the subject, in which I described Mr. Bibbins's method as follows:

> Instead of undertaking a hopeless and aimless quest, as has been done by geologists and collectors in the past, he chose to avail himself of the knowledge of the inhabitants of the districts in which the cycads were believed to occur. Supported by the Woman's College, which furnished him the means of transportation and met the small expense of his work, including an occasional *pour boire* to some needy farmer or miner who possessed information of great value, and usually gave it freely, he proceeded to visit the houses of the native population, and placing himself on a level with their powers of understanding, he was able to interrogate a

[a] Fossil cycadean trunks of North America, with a revision of the genus Cycadeoidea Buckland: Proc. Biol. Soc. Washington, Vol. IX, April 9, 1894, pp. 75–88.

[b] Recent discoveries of cycadean trunks in the Potomac formation of Maryland: Bull. Torr. Bot. Club, Vol. XXI, New York, July, 1894, pp. 291–299.

large number of persons in such a way that they could not fail to comprehend his meaning. Having secured one specimen, he carried it about in his wagon and showed it to all whom he met. His surprise was great to find that a large proportion of the inhabitants of the iron-ore districts had at some time in their lives seen similar things and were able to recognize them. In some cases a person to whom he would show his specimen would reply at once that there was such a stone in his barnyard or near his house, and by a very little negotiation he was able easily to secure it. By far the greater number, in fact nearly all, of the specimens were thus found in the possession of the people. Many of them could remember having ploughed them out of their fields, or taken them from their ore pits; others there were that had lain so long around farmhouses whose occupants had several times changed that it was impossible to trace them to their original source, but usually even in such cases there was a tradition lingering in the family with regard to the peculiar stones. The reason why they were so universally picked up and brought to the house or the workshop or the barnyard or laid up in some conspicuous place seems to be that their peculiarity was instantly recognized. A countryman knows every stone that he has seen about his place, and if there be one which differs markedly from others, especially if it has a certain symmetry of form or shows unusual and regular markings, he at once distinguishes it, is impressed by its appearance, and probably, at first at least, couples with the notion of its strangeness some vague idea of its possible utility or money value. He therefore invariably picks it up and sequestrates it in some way. After many years, finding that there is no demand for it, that no one knows any use to which it can be put, he eventually loses interest in it and it is pushed aside, forgotten, and perhaps covered up in some obscure corner. So that in addition to the specimens that Mr. Bibbins actually obtained, there remain quite a number which are known to exist, but which for the present can not be found.

Mr. Bibbins always frames his questions with skill, taking care not to ask leading ones, realizing that the desire to please is liable to color the answer and make it conform to what it is supposed he desires to have said. He therefore always takes pains to induce these people to tell what they know independently of any suggestion on his part.

As an illustration of the accuracy with which such persons often observe and remember facts may be mentioned a case in which one of these traditional lost specimens was being inquired after from an octogenarian who remembered seeing it some forty years before, and when asked if the "holes" in the stone were "round" he replied, "No, they were sort o' three-cornered," a remark which rendered it certain that the object was really a cycad (pp. 295–296).

Mr. Bibbins continued to secure cycads and send them to me. Many trunks were found in the iron-ore region and brought to him by the inhabitants, who were now thoroughly interested in the subject. Prof. P. R.

Uhler kindly consented to have the four specimens that he had obtained at various times, and which were in the museum of the Maryland Academy of Sciences, included in my report on the cycads of Maryland, and he invited me to come to the academy and describe them. This I did in January, 1895, at which time I also described the two trunks and two fragments that were then in the geological museum of Johns Hopkins University (see p. 482). I then supposed that these two fragments were the same that Professor Fontaine had described.

On this occasion, at Professor Uhler's invitation, I delivered at the Peabody Institute two lectures on the "Vegetation of the Ancient World."[a]

Many additional trunks and fragments obtained by Mr. Bibbins in 1895 were sent me in the fall of that year, which I worked up during the winter. They continued to come during the whole of 1896, and in February, 1897, I was ready to prepare descriptions of the species. Of these I was then able to distinguish 7 as the result of a somewhat careful study of all the Maryland cycads[b] known to me at that date. This paper was not illustrated, and the figures given in the group represented in my paper in the Sixteenth Annual Report of the United States Geological Survey[c] could not then be named. In my later paper on the Black Hills, in which the numerous cycads from that region were systematically dealt with, I introduced a group of Maryland cycads[d] for comparison and appended the names of the species. This group contains 6 of the 7 species. The one species not figured there is *Cycadeoidea Tysoniana*, which was included in the group on pl. c of the Sixteenth Annual Report, being fig. 2 of that plate. They are, however, all described and figured in the present paper, as well as the two additional species that have been discovered since that time.

The entire collection of Maryland cycads loaned by the Woman's College was returned on December 14, 1897.

As the history of Mr. Tyson's early discoveries of cycads in Maryland has never been written, I insert the following extracts from letters

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[a] See note in Science, n. s., Vol. I, Feb. 1, 1895, p. 138.

[b] Descriptions of the species of Cycadeoidea, or fossil cycadean trunks, thus far discovered in the iron-ore belt, Potomac formation, of Maryland, by Lester F. Ward: Proc. Biol. Soc. Washington, Vol. XI, March 13, 1897, pp. 1–17.

[c] Part I, pl. c following p. 486.

[d] Nineteenth Ann. Rep. U. S. Geol. Surv., Pt. II, 1899, pl. lx

received from Sir William Dawson in 1897. I sent him my several papers relating to cycads, and in his letter dated April 19, 1897, he wrote:

I am glad that you are bringing out the discoveries of my old friend Tyson. When in Baltimore in 1868, now nearly 30 years ago, I went over some of his ground with him, and saw specimens of his cycads and coniferous wood, collecting some of the latter on the clays. He asked me to write about them, but I could not then work at Mesozoic things, being entirely occupied with the Devonian floras. I knew, however, that Carruthers was cataloguing the British cycads in the British Museum, so I sent Tyson some manuscript notes on the coniferous wood, and sent a photograph of one of his cycads to Carruthers, which led to his making the note on it you have referred to. Tyson also gave me a specimen for our College Museum, which is still there, and Carruthers returned the photograph, which I still have.

In replying to this letter, on May 14th, I said:

I have seen it stated in one or two places that Tyson referred the cycad beds of Maryland to the Wealden. He does not do this in either of his reports as State chemist of Maryland, published in 1860 and 1862. One of the statements I have seen was made by you in your paper "On the Mesozoic Floras of the Rocky Mountain Region of Canada" (Trans. Roy. Soc. Canada, Vol. III, Sect. 4, 1885, p. 18). Can you inform me whether Tyson ever said this in print; and if so, where?

I did not know that you had one of the Maryland cycads. If you could send me a photograph of it I presume I could name it from that.

Sir William then sent me not only the trunk but also the photograph that he mentions in his letter, which is the same that he had sent to Carruthers, and upon which the latter based the "Postscript" at the end of his memoir. In his letter dated May 19, 1897, he says:

As to Tyson's cycad, it is a largish trunk, with coarse, large leaf bases, and split down the middle to show the internal arrangements. I shall send you one-half by parcel post or express. . . . The one I have a photograph of seems different from the specimen I am to send. I shall send the photograph also. It is of interest, as being the same I sent to Carruthers.

I fear I can give you no reference as to use of the name *Wealden* by Tyson. I only remember that in going over the ground he habitually called the formation Wealden, and that caused me to say it was supposed to be Wealden in writing to Carruthers about it and perhaps in mentioning it elsewhere, though I do not recall this now. If, however, I can refer to anything of Tyson's I shall mention it when I send the specimen and photographs. At that time we had very little idea of the successive floras of the Jurassic and Cretaceous, and the reference to the Wealden on grounds of paleobotany could, therefore, be regarded as only general. But

Tyson called it so, and not only the flora but the estuarine character of many of the beds agreed with this.

And in another letter written ten days later announcing the shipment of the trunk he adds:

As to the supposed Wealden equivalency of the beds, I have found no printed reference. When I was in Baltimore in 1869 I was delivering some lectures at the Peabody Institute on the origin of coal, and naturally inquired as to fossil plants. Tyson, whose acquaintance I had made sometime before, showed me his cycads and took me to see the excavations for iron ore, in which we found some coniferous wood. I saw no other fossils, but heard that leaves had been found. The cycads and the structure of the conifers sufficed to show that the beds were probably Mesozoic and newer than the Richmond coal field, at that time, I think, regarded as Jurassic. Hence it was natural to regard them as equivalent to the Wealden, and probably older than the marine greensands farther north. That was my conclusion from the little that I saw, and was so entered in my notes at the time; but I do not think I published anything, though I may have referred to it incidentally in later publications.

He was quite right in saying that the trunk sent was different from that shown in the photograph. The latter was a view of one of the type specimens of *Cycadeoidea marylandica*, while the former belongs to my *C. Bibbinsi*. I described the trunk fully in June of the same year and had two views prepared, which are reproduced in the present paper on Pl. LXXXII. (See pp. 416, 456.)

While on the subject of Mr. Tyson's specimens, I will mention two other cases which are certain and a third doubtful case. Sometime after Doctor Newberry's death Dr. Arthur Hollick found among his effects an unmounted photograph of a cycad, and by the side of it three large pieces of petrified wood. On the back of the print was written in Doctor Newberry's handwriting: "Cycadeoidea, Trias ? Maryland. From Professor Tyson." Knowing that I was at the time making a special study of Maryland cycads, Doctor Hollick kindly sent it to me. It is reproduced in this paper on Pl. LXXXI. The trunk can be readily recognized as the type figured by Professor Fontaine on pl. clxxx of his Potomac Flora, but so tilted as to show considerable of the base. It is the Johns Hopkins University type No. 1 (*Cycadeoidea marylandica*). (See p. 414.)

In one of Mr. F. B. Meek's volumes of "Miscellaneous Papers," bound together and now in the library of the National Museum, containing Mr. Tyson's second report inscribed by him to Mr. Meek, there is a photo-

graph, at the end of the book, of three cycads, a large one in the center and a small one on each side of it. This was evidently taken by Mr. Tyson and sent to Mr. Meek. The large central figure is a view of the opposite side of the trunk last mentioned, turned considerably more to the left than it was in the view given in pl. clxxix of Professor Fontaine's monograph, so as not to show the peculiar broad line that runs down one side. The figure on the left is a view of the Johns Hopkins fragment No. 3, also representing *C. marylandica.* (See p. 457.) The figure on the right shows the Johns Hopkins fragment No. 4, belonging to *C. Bibbinsi.* This view is reproduced on Pl. LXXXIII of this paper.

The third case referred to as doubtful is that of a considerable fragment having every appearance of being a Maryland cycad, found by Prof. L. C. Glenn, in the department of geology of South Carolina College, at Columbia, in 1899, and of the existence of which he was so considerate as to notify me. I expressed a great interest to see it, and he sent it on to Washington. He said there was no label whatever nor any indication of its history or source, and we are therefore still left in mystery and can only conjecture what its presence there might mean. The only hypothesis I have been able to make is that Mr. Tyson sent the specimen to some one of his correspondents who was at Columbia at the time he collected the cycads. It proves to belong to *Cycadeoidea Fontaineana,* and is fully treated in this paper. (See Pl. LXXXVI.)

Since the publication of my paper in 1897, describing the 7 species of Maryland cycads, Mr. Bibbins had, by the end of 1901, obtained possession of 37 additional trunks or fragments, and in January, 1901, at his request, I visited the Woman's College and elaborated all this new material. The collection, however, contained two well-marked new species and several good specimens of species only sparingly represented in previous collections, and fragments referable to one or other of the species already described.

STRATIGRAPHICAL POSITION AND GENERAL NATURE OF THE MARYLAND CYCADS.

By Arthur Bibbins.

The trunks of Cycadeoidea thus far yielded by the Potomac group,[a] about 112 in number, appear to have been derived from within the State

[a] The author, following the nomenclature of the Maryland Geological Survey, treats the Potomac as a "group" and designates its subdivisions "formations."—L. F. W.

of Maryland, and nearly all from that section of the Potomac belt which lies between the city of Baltimore and the District of Columbia.

The width of that zone of the Potomac belt which includes the supposed original sources is about 10 miles, the vertical range being from tide level up to 300 feet.

The following table shows the taxonomy of the Potomac group, as well as the relations of its deposits to the subjacent and superjacent terranes, according to the usage of the Maryland Geological Survey. The accompanying map and sections published by this Survey, Pl. LXXX, shows the distribution of the formations of the Potomac group in Maryland and their stratigraphic relations. The principal localities for fossils have been added. For a full discussion of the taxonomy of the Potomac beds employed in this paper, together with its correlation with other taxonomies, the reader is referred to the paper cited on p. 520 above.

Table showing the relations of the formations of the Potomac group to subjacent and superjacent terranes.

Group.	Formation.	Age.	Origin.	Lithology.
Columbia	Talbot	Pleistocene	Fluviatile	Clay
	Wicomico or Sunderland.	Pleistocene	Estuarine and marine	Loam, peat, sand.
		Pleistocene		Gravel and conglomerate.
	Lafayette	Pliocene		
Chesapeake	Calvert	Miocene	Marine	"Marlite," etc.
Pamunkey	Aquia	Eocene	Marine	Glauconitic marls.
Severn	Matawan	Upper Cretaceous	Marine	Clay marls, glauconitic and carbonaceous.
Potomac	Raritan	Lower Cretaceous	Estuarine	Sands and clays.
	Patapsco	Lower Cretaceous	Estuarine	Clays and sands.
	Arundel	Upper Jurassic	Estuarine?	Clays.
	Patuxent	Upper Jurassic	Estuarine?	Sands and clays.
	Newark[a]	Triassic	Estuarine and igneous.	Red sandstone, limestone, breccia, shale, and trap.
	Algonkian	Pre-Cambrian	Metamorphic, sedimentary, and igneous.	Crystalline rocks.

[a] The Newark is usually wanting in the section, and the overlying formations frequently so. When the latter are present only one or two commonly occur at the same time to the landward, while to the seaward there may be several.

Only one of the Potomac cycad trunks (W. C., B., No. 1481) is positively claimed to have been seen in situ, its alleged bed being a compact argillaceous sand near the summit of the Patuxent terrane. With a few

possible exceptions the trunks appear to have been derived from more or less arenaceous deposits, referable either to this or to the Patapsco formation. There is no very definite evidence that the Arundel, which is a highly argillaceous terrane, has yielded any, unless, possibly, by secondary deposition from the Patuxent formation. Most of the vegetable tissues embedded in the Arundel are either carbonized or replaced by iron, silicification at times occurring near its contacts with the more arenaceous Patuxent and Patapsco terranes or well to the landward, where its deposits tend to be somewhat arenaceous within the formation itself. Near the Patapsco contact, for example, a coniferous trunk partly lignitized and partly silicified was found, and a silicified coniferous trunk was excavated from an Arundel sand lens near Brookland. The circumstance that lignitized cycad trunks have never been reported by the Arundel iron miners should not, however, carry much weight, since if occurring they would doubtless be compressed or otherwise distorted and therefore much less readily recognized. Besides, unless the trunks occurred more commonly than in the Patuxent and Patapsco formations, the chances of their being encountered at all by the iron miners would be very slight, for no one has ever been known to exhume a silicified cycad trunk from the perhaps equally numerous Patapsco and Patuxent excavations for sands and gravel. One must not infer, therefore, that the cycadaceous element of the vegetation of Arundel times was necessarily less prominent than that of the Patuxent and Patapsco epochs. The fact that there was such an element in the Arundel flora is shown by the occurrence of frond impressions in its clays and iron ores. The conditions for the entombing of the trunks may at that time have been less favorable, as the conditions of permanent preservation in such a form as to favor detection certainly were.

There is no very definite evidence that any of the trunks have been derived from the Raritan terrane, though several may well have been. The most probable case is that of the trunk, W. C., B., No. 6346, found north of Woodwardville, but the point at which that trunk was found is not positively known. Moreover, its much worn condition suggests redeposition in the Pleistocene.

That the original beds of the trunks were certainly largely arenaceous instead of argillaceous is proved by their silicification, hereinafter mentioned, though semisilicified coniferous wood is occasionally found in slightly sandy clays.

Still further evidence is supplied by the fact that in a large number of cases pebbles and coarse sand are firmly cemented to or lodged in the alveoli of the trunks. In some instances, however, there is evidence that these pebbles and sand grains are of later origin. One trunk, for example (J. H. U., No. 1), exhibits a definite pebbly conglomeratic zone, which does not lie in the plane of compression (see Pl. LXXXI). Moreover, the variety in composition of the pebbles of this zone is suggestive of their origin from redeposition in the Pleistocene, as is also the somewhat worn condition of the trunk. The complete or nearly complete trunks range in size from about 28 by 20 by 15 cm. to 49 by 45 by 25 and 50 by 42 by 13 cm.

The tissues of all the trunks are replaced by silica, and there are occasional coatings of quartz druse. Mineralogically the fossils are pseudomorphs after cycadean trunk tissues. The histology[a] is evidently not so faithfully preserved as that of the trunks from the Black Hills. Their megascopic characters, both external (Pl. XCIX) and internal (Pl. XCVI), are, on the contrary, somewhat more satisfactorily shown.

In hardness the trunks show considerable variation, ranging between 5 and 7, apparently due to varying porosity. The specific gravity of the hardest and least porous pseudomorphs is about 2, 1.

The trunks commonly exhibit strong compression like those of silicified coniferous wood with which they are often associated. The flattening is usually lateral, showing that the trunks were usually embedded in prostrate position. From this fact and the circumstance that all of the sands of the Potomac group are current bedded, one may infer that the trunks were probably transported by water before being entombed. A few are compressed from above downward (Pl. XCIV) and a few obliquely (Pl. LXXXVII, Fig. II, 10).

The cross sections of the complete trunks are therefore usually elliptical in outline (Pl. LXXXIII, Fig. 4). Their longitudinal sections range from a well-defined oval (Pl. XCIX), with the enlargement toward the base, through subrectangular (Pl. CI), to an inverted trapezoid (Pl. CVI). The outlines of the complete trunks are suggestive of those of such objects as the pineapple, pine cone, sponge, thatched beehive of the old pattern, wheat stack, etc., most of which terms, as will later be seen, were

[a] The internal structure and history of the Maryland cycads will be considered in a subsequent paper.

employed by the residents in describing them. A few of the fragments are suggestive of considerable elongation not unlike that of the modern *Cycas revoluta* or Macrozamia. In these cases, however, the shape of the trunk appears to be governed to some extent by the food supply—uniformity producing a regularly cylindrical trunk, and want of it an irregular conical one.

The so-called "crow's nest" is in a few cases very well defined. The best of these occurs in the Turner trunk (Pl. XCV), which, as already stated, was long in use as a watering trough for domestic fowls.

The considerably weathered and etched condition of the fractured surface of most of the fragments indicates that the fractures are of considerable age. This conclusion receives some confirmation by the fact already suggested that, save in a single instance (W. C. B. Nos. 1659 and 1659a), a second fragment has never been found near the first. In the case of the exception the fracture is evidently not recent, as supposed by the plowman who unearthed it, and this is the only instance in which two fragments have ever matched together.

The color of the trunks is identical with that of the silicified coniferous wood which is not unfrequently associated with them. When newly unearthed they are light and dark buff to reddish brown or brownish red, dependent upon the amount of hydrous iron oxide present in their original or secondary beds. After exposure to the weather for some time they are apt to assume darker tints—light and dark gray being the most common.

Respecting the frequency of occurrence of the Potomac cycad trunks, it should be stated that, while the number of specimens which have been brought to light within a comparatively short time is considerable, this is due rather to the adoption of a successful method of searching than to the actual abundance of the fossils. They are really so scarce that there is little chance of one being secured from the field by direct search. No one, in fact, has ever been known to do this, all having thus far been found by accident. It is rarely that more than one trunk has been noted in a given locality, but there are a few notable exceptions to this rule. Though the cycad trunks are of considerably less frequent occurrence than the silicified trunks of conifers, it may be said that there was a goodly showing of the cycadaceous vegetation in the forests of Potomac times.

When it is remembered that the chances of preservation for silification of the less woody and more pulpy tissue of the cycads were probably much less favorable than that of the conifers, one is permitted to suppose that the preponderance of the latter, as suggested by the more common occurrence of their remains, may not, after all, have been very considerable.

DESCRIPTION OF THE SPECIES OF MARYLAND POTOMAC CYCADS.

The whole number of specimens that have come into my hands for description to the present date (September, 1902) is 105. A final study of this material results in the separation of them into nine specific groups; in other words, nine distinct species. I refer them all to the genus Cycadeoidea of Buckland, which has been fully described in earlier papers and its systematic position discussed (see p. 216). It may be illustrated by two groups representing the finest specimens of the Maryland cycads.

Genus CYCADEOIDEA Buckland.

CYCADEOIDEA MARYLANDICA (Fontaine) Capellini & Solms-Laubach.

Pl. LXXXI; Pl. LXXXII; Pl. LXXXIII, Figs. 1, 2, 4; Pl. LXXXIV, Figs. 1, 2; Pl. LXXXVII, Figs. II, 3, 5, 6, 7; III, 1, 4; IV, 4, 5, 12, 13, 14; V, 2, 3, 5, 6, 7, 17; Pl. LXXXVIII; Pl. LXXXIX, Figs. II, 3, 4, 7; III, 2, 5, 8; Pl. XC; Pl. XCI; Pl. XCII.

1860. *Cycas* sp. Tyson: First Report State Agric. Chem. Maryland, p. 42.
1870. *Bennettites* sp. Carr.: Trans. Linn. Soc. London, Vol. XXVI, p. 708.
1879. *Cycadoidea* sp. Font.: Am. Journ. Sci., 3d Ser., Vol. XVII, p. 157.
1889. *Tysonia Marylandica* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 193, pl. clxxiv–clxxx.
1892. *Cycadeoidea Marylandica* (Font.) Cap. and Solms.: Mem. Real. Accad. Sci. Ist. Bologna, Ser. V, Vol. II, pp. 179, 180, 186.
1897. *Cycadeoidea Marylandica* (Font.) Cap. & Solms. Ward: Proc. Biol. Soc. Washington, Vol. XI, p. 9.

Trunks of medium or rather large size, almost always more or less laterally compressed so as to be elliptical in cross section, conical in shape or slightly narrowed near the base with a terminal bud set in a slight depression at the summit, simple, or in one specimen, apparently having one branch; mineral constitution very variable according to mode of preservation, but usually not hard, flinty, nor heavy and compact; reddish, pinkish, drab, or ash colored; 25 to 45 cm. high, 24 to 40 cm. in longer and 12 to 26 cm. in shorter diameter, with a girth of from 70 cm. to one

meter; organs constituting the armor proceeding at a right angle to the axis except above, where they are ascending, and near the base, where they are sometimes slightly descending; leaf scars arranged in two series of spiral rows crossing each other usually at a different angle to the axis of the trunk, the angle varying from 30° to 75°; scars usually subrhombic, i. e., with the lateral angles nearly equal and the vertical ones unequal, the lower more acute than the upper, the latter often reduced to a mere groove or wanting entirely, and the two upper sides together forming an arch, the whole scar simulating a drawn bow and bowstring, but sometimes triangular, the upper sides joined along a horizontal line or more irregular in shape, occasionally with four curved sides and four acute angles; the width as represented by a line joining the two lateral angles varying from 15 to 25 mm., and the height as represented by a line joining the two vertical angles (which would rarely be parallel to the axis of the trunk) varying from 6 to 15 mm.; remains of the petioles usually present in the scars at different distances from the summit, often bearing evidence of having been disarticulated at a natural joint, sometimes indicating the existence of two such joints at different depths in the scars, and showing that these joints consist of a diaphragm across the petiole which may remain after the substance of the petiole has partly decayed below it, leaving a hollow space, portions of the outermost diaphragms also sometimes adhering to the sides of the scars in the form of a ridge surrounding them; vascular bundles rarely visible under an ordinary lens, but occasionally seen in the form of a row near the outer margin all round the leaf base with a few near the center; ramentum walls usually rather thick, but varying from less than 1 mm. to 9 mm., ordinarily with a more or less distinct line marking the junction of the parts belonging to adjacent petioles (commissure), sometimes with a distinct plate or layer of less compact tissue between these, occasionally but rarely affected with pits or small bract scars, especially in the angles; reproductive organs usually abundant, often solid and protruding, generally more or less distinctly marked in the center by the remains of the essential organs and surrounded by bract scars in several concentric rows, but often decayed in various degrees, leaving corresponding funnel-shaped cavities, commonly elliptical in cross section, wider than high, very variable in size, the major axis 15 to 40 mm. and the minor 10 to 30 mm.;

armor thin, 2 to 5 cm., usually joined to the internal parts by a clear line, but without measurable thickness, but sometimes very irregularly so joined and occasionally showing a thin libro-cambium layer; woody zone 3 to 10 cm. thick, usually with two or three more or less distinct rings, the outer or parenchymatous zone thicker and firmer than the inner or fibrovascular zone; medulla usually homogeneous in structure, elliptical, the major axis 8 to 17 cm., the minor 3 to 9 cm.

This is historically the most important species of Maryland Potomac cycads, most of the original types found by Tyson belonging to it. It is also the most abundant species, the whole number of trunks and fragments now known amounting to 28, an increase of 10 since 1897, when I was able to record 18 specimens. To this species also belongs the Link trunk, the only one that has been actually seen in place.

The following is the list of these 28 specimens, chiefly in the order of their discovery, as denoted by the numbers assigned to them in the different institutions to which they belong, and accompanied by their vernacular and folklore names, so far as they have received such, and by their weights expressed in kilograms and decimals of kilograms, with the abbreviations described on page 751a:

	Weight in kilograms.
J. H. U. Cycads, No. 1	40.37
J. H. U. Cycads, No. 2	24.94
J. H. U. Cycads, No. 3	3.18
J. H. U. Cycads, No. 5	10.89
Md. Acad. Cycads, No. 1	18.14
W. C., B., No. 1192, the Tubbs fragment	3.74
W. C., B., No. 1428, the Crook fragment, No. 1	8.39
W. C., B., No. 1481, the Link trunk	18.14
W. C., B., No. 1486, the Harrison fragment ("wasp's nest")	.47
W. C., B., No. 1656, the R. T. Donaldson fragment, No. 2	.79
W. C., B., No. 1657, the D. O. Donaldson fragment	.45
W. C., B., No. 3050, the Harwood trunk	7.03
W. C., B., No. 3051, the Morgan trunk	2.72
W. C., B., No. 3056, the Lester trunk	7.03
W. C., B., No. 3057, the Owens fragment	4.20
W. C., B., No. 3324, the R. T. Donaldson fragment, No. 3	9.74
W. C., B., No. 3328, the Helwig trunk	11.79
W. C., B., No. 3341, the R. T. Donaldson fragment, No. 6	2.72
W. C., B., No. 6343, the R. P. Disney trunk	4.55

	Weight in kilograms.
W. C., B., No. 6344, the Reinsnyder trunk	4.56
W. C., B., No. 6349, the R. T. Donaldson fragment, No. 7	1.25
W. C., B., No. 6350, the R. P. Disney fragment, No. 3	.70
W. C., B., No. 6358, the R. P. Disney fragment, No. 5	1.81
W. C., B., No. 6359, the R. P. Disney fragment, No. 6	2.89
M. G. S.-W. C., B., No. 8319, the R. T. Donaldson fragment, No. 8	.72
M. G. S.-W. C., B., No. 9046, the Allen fragment, No. 1	2.72
M. G. S.-W. C., B., No. 9058, the R. T. Donaldson fragment, No. 14	1.13
M. G. S.-W. C., B., No. 9065, the R. T. Donaldson fragment, No. 17	.72

In Mr. Bibbin's contribution to the Original Sources of the Maryland Cycads, and in the chapter on their Folklore compiled by Miss Hopkins from the data collected by him, it was found advantageous to introduce illustrations of most of these historic specimens. These illustrations will be enumerated here, along with such additional ones as it has seemed necessary to introduce.

Pl. LXXXI represents the Johns Hopkins cycad No. 1, as photographed by Tyson along with a quantity of silicified wood, and is a reproduction of the view sent by him to Doctor Newberry and found among his effects by Doctor Hollick. The circumstances, so far as known to me, are described in the historical part of this paper (p. 414). The specimen was inclined away from the camera so as to show the base. It is a fine and nearly perfect trunk, more or less conical in shape, but somewhat elliptical in cross section, perhaps from lateral compression. It tapers both ways, but only slightly downward. At the summit it is much smaller, rounding off more rapidly on one side than on the other, as shown in Professor Fontaine's pl. clxxix, Monogr. U. S. Geol. Surv., Vol. XV. The axis is seen to fairly good advantage from the base. At the summit there is a cavity or "crow's nest" 14 cm. across, with a somewhat definite rim, succeeded by a nearly flat depression marked very clearly by small scars of polygonal shape or nearly circular. These average about 6 mm. in diameter. Some of those at the outer margin are subrhombic, and evidently represent small leaves or bracts. The inner polygonal ones may represent floral organs. The material with which they are filled is marked at the summit by somewhat definite pits or scars, as of special organs. The center of this apical depression is occupied by a terminal bud 5 cm. in diameter and 13 mm. high. It is irregularly covered with

scars of varying sizes, but all smaller than those last described. Only one-half of this crow's nest is preserved, the other half, including a very little of the terminal bud, being eroded away, leaving a deep cavity, the sides of which show no structure. The specimen is of a dark-reddish color, well silicified, and heavy. It stands 43 cm. high, is 35 cm. in the major axis of a cross section at the largest part, some 15 cm. above the base, and 26 cm. in its minor axis. The girth at the same point is 98 cm., while at the summit just below the break it is 86 cm.

The peculiar vertical seam or broad mark seen on the side of this view, and still better in the views published in Professor Fontaine's monograph, pl. clxxix, clxxx, deserve special notice. It was described by Professor Fontaine on p. 191 of the text of his monograph as "a projecting seam of ferruginous silica. This is shown on the narrower side of the trunk on pl. clxxx, and less distinctly on the front left-hand side on pl. clxxix. This seam appears to be due to a crack in the trunk, which was filled with infiltrated silica in the form of a vein. This silica in the projecting plate or vein seems to be in part at least due to a partial filling of the crack by sand, for grains of sand are mixed with the silica deposited from solution."

On January 9 and 10, 1895, I described all the specimens then known to be at the Johns Hopkins University geological museum, including this one, and wrote out my descriptions in full. In dealing with this feature I found myself unable to agree with the interpretation of Professor Fontaine. The following are my description and conclusions, as then and there recorded, from which I have not since seen any reason to recede:

> The peculiar and conspicuous line that encircles this specimen from top to bottom and is seen in all the photographs is not due, as Professor Fontaine supposed, "to a crack in the trunk, which was filled with infiltrated silica in the form of a vein," but is wholly superficial. It consists of a mainly dark ferruginous coarse sand approaching gravel and thickly studded with larger white grains, mainly of worn vein quartz, often small pebbles, and all firmly cemented. It has a width of a little over half an inch and can be traced continuously around the specimen, very distinct on both sides, less so where it traverses the base and summit. It fills all the leaf scars and other depressions and appears in the form of a vein or dike uniform with the extreme outer surface. But in most cases where it is crossed by the ramentum walls these are seen perfectly intact passing through it. It does not pass round the center of the specimen but much to one side, like a milky way, so that should the trunk be split along that plane most of the axis would be in one of the parts.

My theory of its origin is that the trunk lay for a long period on its side in just such a way that this plane would be horizontal; that while so lying it was buried in a deposit of the sand, gravel, and pebbles described; and that it so happened that one of the well-known seams of iron incrustation was formed at that level and to that thickness. This penetrated the openings in the stone and probably adhered to it, forming a wing all round it until some agency wore it off to the level of the general surface of the specimen. (Locality: Pl. LXXX, No. 97.)

Pl. LXXXII represents the most perfect side of Johns Hopkins University Cycad No. 2, and is a reproduction of the photograph made by Mr. Tyson and sent by him to Sir William Dawson, of which a full account is given in the historical part of this paper (pp. 409–416). This is a fine trunk, with one side complete from base to summit. It is considerably compressed laterally. The base is broken across obliquely in the direction of the major axis, but so as to leave one-half intact. On the same side that is broken at the base there is a large cavity eroded out of the summit, as shown in Professor Fontaine's pl. clxxvi. The summit itself is occupied by a normal depression or crow's nest, with a terminal bud in the center much lower than the surrounding rim. The eroded cavity is at one side of the terminal bud. I do not think that it represents another bud or axis of growth, as suggested by Professor Fontaine. The specimen is of a rather light-reddish color, well silicified, but not hard or heavy. It stands 35 cm. high. The major axis of a cross section just above the base where thickest is 35 cm. and the minor axis 24 cm. The latter rapidly diminishes upward to 15 cm. at the summit (see Professor Fontaine's pl. clxxv), but the major axis decreases much less to near the summit, where it rounds off abruptly, as shown in pl. clxxiv and pl. clxxvi. The maximum girth is 85 cm., but this is above the middle, below which point the basal fracture prevents measurement. It was probably nearly 1 meter near the base. The specimen is remarkable for the number and conspicuousness of the floral axes. Some of these are 3 cm. or 4 cm. in diameter. Sometimes the center is gone, but in most cases it is present and either solid or pitted all over with the scars of the involucral or seminal organs arranged concentrically. A number of these large axes protrude in a marked manner, and one which occurs at the margin of the fracture resembles *Bennettites Morierei*. Professor Fontaine fancied he detected two classes of these organs, but I am unable to see any generic difference in the lateral flower buds. Some protrude

and others not; some have the center decayed and some seem to consist more of bracts than essential organs; but I think that difference of age would account for all these differences. Some are probably quite young and immature, others fully ripe, and still others old and ready to decay. (Locality: Pl. LXXX, No. 91.)

Pl. LXXXIII, Fig. 1, the central figure of the group shown in the photograph sent by Mr. Tyson to Mr. F. B. Meek, of which an account was given in the historical part of this paper (p. 414), is another and quite different view of the Johns Hopkins University Cycad No. 1. It is nearly in the same position as that of Professor Fontaine's pl. clxxix, but the trunk was inclined toward the camera so as to show the summit. The ferruginous band is seen running the whole length of the trunk on the left.

Pl. LXXXIII, Fig. 2, on the left of the figure last considered, is a view of the Johns Hopkins University Cycad No. 3, described by Professor Fontaine on p. 192 of his monograph as "Fragment No. 2," but not figured by him. It is not shown here to the best advantage and will be mentioned again in the description of the next plate.

Pl. LXXXIII, Fig. 4, is a view of the base of the Link trunk (W. C., B., No. 1481.)

Pl. LXXXIV, Fig. 1, is a side view of the Johns Hopkins University cycad No. 5, described by Professor Fontaine as "Fragment No. 2." At the time I described the specimens, in January, 1895, it was not with the other specimens and I did not treat it. It was discovered soon after in the basement and I was notified of the fact. On May 11 of that year I described it and had the photograph made which constitutes Pl. LXXXIV, of which it occupies the center (Fig. 1), the fragments Nos. 2 and 4, not previously figured, occupying the left and right (Figs. 2 and 3), respectively. The specimen seems to consist of a little over half of a trunk of medium size of conical shape and elliptical cross section. It is truncated at the summit and oblique at the base. As stated by Professor Fontaine on p. 191 of his monograph, it has a circle of cemented ferruginous sand similar to that of No. 1, which, like that, is wholly superficial. In this case, however, the plane at which the formation of this ferruginous cement took place was much below (or possibly above) the center of the trunk.

It is of a dark iron-red color, well silicified, moderately hard, and heavy. The height along the longest edge is 32 cm., but along the shortest edge it is only 22 cm. At the middle above the oblique base where widest it has a breadth of 23 cm., indicating a major axis for the trunk of 30 or 35 cm. The minor axis at the base, one side of the center to miss the fracture, is 18 cm. Measured over the circumference, 43 cm. are found to be preserved here. The radial thickness below is 12 cm., and 9 cm. at the summit. (Locality: Pl. LXXX, near No. 34.)

Pl. LXXXIV, Fig. 2, represents the Johns Hopkins University cycad No. 3 in a much better position than it was shown in the view sent by Tyson to Mr. Meek (see Pl. LXXXIII, Fig. 2). This specimen was described by Professor Fontaine on pp. 190–191 of his monograph as "Fragment No. 1," but not figured. It is a segment from the side of a trunk that has suffered from vertical compression. Its only remarkable feature is what seems to be a true branch or secondary axis near the upper edge which rises about 3 cm. above the general surface. It is surrounded by leaf scars and shows at the center a well-defined axis, apparently vascular, with very small tubes irregularly scattered through it. The branch is elliptical in cross section, the longer diameter being horizontal and 8 cm. and the shorter vertical and 5 cm., while the axis, also elliptical, is 20 mm. by 10 mm. thick. The fragment is soft and friable and of a light-ash color, pure white within, as shown where freshly broken or bruised, appearing as if calcareous. (Locality: Pl. LXXX, near No. 129.)

Most of the specimens at the Woman's College were arranged in a large group and photographed in 1900. This group includes, besides all the principal types, a large number of less important specimens and small fragments that are not otherwise illustrated. The view is introduced here as Pl. LXXXVII, and the specimens included in it are treated as figures of that plate. Being arranged in tiers it has been found convenient in finding the figures to number the tiers in Roman from below upward, I–V, and the figures from left to right on each tier in Arabic. Seventeen of the figures of this group represent specimens referred to *C. marylandica*. These will be taken up in the order of the figures, and those not elsewhere figured will be described.

Pl. LXXXVII, Fig. II, 3 represents the Link trunk, W. C., B., No. 1481, whose history has already been given and which will be fully described below.

Pl. LXXXVII, Fig. II, 5 shows the Reinsnyder trunk, W. C., B., No. 6344, which is a large piece from the flattened edge of a tall, compressed trunk, of low specific gravity and soft structure, stained reddish pink. It probably reaches nearly from base to summit and is 38 cm. high. It is only 14 cm. thick at the lower end, and thins out upward, becoming only 8 cm. near the top, where one of the sides disappears. It is 15 cm. wide, but this does not reach the middle of what was the broad side. The armor and wood are pressed close together, leaving only a thin slab of medulla between. The scars, though distorted, show well on the surface and resemble those of the Helwig trunk, W. C., B., No. 3328. (Locality: Pl. LXXX, No. 54.)

Pl. LXXXVII, Fig. II, 6 gives a side view of the Helwig trunk, W. C., B., No. 3328, one of the leading types of the species, already mentioned and to be treated at length.

Pl. LXXXVII, Fig. II, 7 shows, partially obscured by overlapping, the R. T. Donaldson fragment, No. 3, W. C., B., No. 3324. This is a large piece from one side of a laterally much compressed large trunk, the fracture passing nearly parallel to the short axis. The outer portion is preserved well all round to the fracture on both sides. The fragment extends from the base to very near the summit, toward which it regularly tapers, as if the complete trunk before compression had been dome-shaped. It is of a light-ash color and the rock is fine grained, hard, and heavy. It stands 38 cm. high, has a maximum radial width of 19 cm., and varies in thickness from 15 cm. at the base to 6 cm. at the thinnest place near the summit. The partial girth over the outer surface measures 40 cm., and the height as measured along the curving edge is the same. (Locality: Pl. LXXX, No. 106.)

Pl. LXXXVII, Fig. III, 1 is a view, also partially hidden by the specimen on the shelf below it, of the Lester trunk, W. C., B., No. 3056. It is a small trunk, nearly complete, but lacking portions near the summit. It is elliptical or oblong in cross section, nearly uniform in size all the way. The base is probably the same as when growing. There is a cavity at the summit showing the top of the medulla, and on one side a large piece has decayed. Smaller pieces have been broken at the two ends of the ellipse. The external surface has suffered somewhat from wear at various points. The rock is moderately firm and of a dull-orange color, with

dark parts. Its specific gravity is about that of the average cycad. The trunk is 16 cm. high, 25 cm. in its major and 17 cm. in its minor diameter, and it has a girth of 71 cm. (Locality: Pl. LXXX, No. 132.)

Pl. LXXXVII, Fig. III, 4 represents part of one side of the Crook fragment, No. 1, W. C., B., No. 1428. This is a segment of the basal portion of a smallish trunk, divided somewhat evenly by a plane passing vertically a little to one side of the center, preserving the larger half. The specimen is somewhat compressed laterally, and this plane passes through at an angle of about 40° to the major axis of the ellipse. The fracture across the upper end is also nearly even and horizontal, presenting a cross section of the trunk, while that through the center affords a radial section. The base is oblique and indicates a deep depression in the center, but these irregularities are not due to fracture nor to decay in the process of silicification. This latter process has proceeded very far, and there is much crystallization, with a tendency to chalcedony, especially in the interior portion. The rock is therefore firm and heavy. The color is a dark gray, lighter within, and slightly reddish about the base. The maximum height is slightly more than 20 cm. This is reduced to 12 cm. on the inner side, owing to the oblique base. The greatest diameter is 24 cm., the distance across the fracture being 23 cm. The half girth is 43 cm., which indicates a total girth of about 80 cm. (Locality: Pl. LXXX, No. 53.)

Pl. LXXXVII, Fig. IV, 4 is a side view of the R. P. Disney trunk, No. 1, W. C., B., No. 6343. It is a large, imperfectly preserved piece of a much flattened trunk, the armor and wood inclosing a slab of medulla 4 cm. thick, which projects 3 cm. farther inward. The trunk is of a dull-gray color and heavy texture, and the large scars are greatly distorted and present a rough, harsh exterior. It probably extends to near the base. The length is 32 cm., the width 21 cm., and the thickness 12 cm. This specimen is anomalous, and is doubtfully referred to *C. marylandica*, its nearest affinities being to W. C., B., Nos. 1481 and 3324. (Locality: Pl. LXXX, near No. 50.)

Pl. LXXXVII, Fig. IV, 5 gives a good view of the best side of the Harwood trunk, W. C., B., No. 3050. This is a portion of a large trunk, much compressed laterally and also vertically, and greatly distorted. It shows considerable of the outer surface, including the imme-

diate summit, which is mostly flat, with the exception of a small round depression at the center. The longitudinal fracture passes near this depression. This apical portion adheres to one side of the flattened fragment, but is connected with the outer portion shown on the opposite side by a continuation of the armor over the thin edge. Below it all has disappeared and the internal parts are exposed. There is a longitudinal fracture and a horizontal fracture at right angles to each other, so that, seen from the broad side, it has somewhat the shape of a quadrantal sector, though longer, and a triangular piece is wanting at the summit.

The extreme height is thus about 27 cm., but this projects 8 cm. beyond the true physiological apex. The maximum width is 18 cm., but the radial fracture is only 15 cm. The thickness, which is mainly at right angles to the leaves, but is nearly parallel to those of the apical portion, varies from 5 cm. at the lowest part to 13 cm. opposite the terminal portion. The partial circumference formed by the thin edge is 38 cm., while that measured over the broad side is 33 cm. The specimen is of a light-ash color, varying to yellowish within. The substance is fine grained and firm, but of medium specific gravity. (Locality: Pl. LXXX, No. 44.)

Pl. LXXXVII, Fig. IV, 12 shows standing on its edge (i. e., lying down), the outer surface of the R. T. Donaldson fragment, No. 6, W. C., B., No. 3341. This fragment came from the side of a medium sized trunk, apparently remote from both base and summit, consisting of the armor and at least one ring of the woody zone. It is convexo-concave, so as to make the cross section crescent-shaped. The inner concavity is exaggerated so as to form a central depression or trough. Nearly the whole inner surface is thus eaten away, the softer much deeper than the harder parts. The effect is to leave projections of the latter and to give the surface a studded appearance. The outer parts are imperfectly preserved, the armor being quite absent over the lower fourth of the specimen. It seems also to have suffered somewhat from vertical compression. The fragment is of a uniform light-ash color, rather fine grained, but soft, and apparently somewhat argillaceous. The specific gravity is low. The length (height) preserved in the fragment is about 14 cm., the tangential length 23 cm., and the radial thick-

ness 10 cm., more or less. The arc of the outer surface measures 25 cm.; that of the inner surface about 16 cm. (Locality: Pl. LXXX, No. 106.)

Pl. LXXXVII, Fig. IV, 13 shows most of one side of the Tubbs fragment, W. C., B., No. 1192, the first specimen obtained by Mr. Bibbins. It is a small segment from the side of what seems to have been a large trunk. A surface view of the fragment is somewhat wedge shaped, the smaller end downward and truncated. This surface is very much worn, so much so on one side as to have nearly obliterated all the markings. On the inner side it consists of a triangular segment of the woody zone sloping upward and downward and presenting a sharp inner edge horizontally across the specimen. The color of the outer parts is a lively red, such as that of the paint stones and clays of the iron-ore belt. Internally it is light colored. The substance is hard and fine grained, giving it a high specific gravity. The height is 18 cm., the maximum lateral surface shown, including a slight curvature, 19 cm., while below it is only 10 cm. across. The radial distance from the surface to the sharp ridge above described is 12 cm. (Locality: Pl. LXXX, No. 46.)

Pl. LXXXVII, Fig. IV, 14, represents the Morgan trunk, or rather fragment, W. C., B., No. 3051, a somewhat triangular fragment from the thin side of a vertically compressed trunk, the tangential and radial fractures being at right angles and passing through the armor into the woody zone. The color is whitish pink, very delicate, unlike that of any other specimen in the collection. The substance is rather soft and friable. The maximum length in a tangential direction is 21 cm., the radial thickness 13 cm., and the third dimension or vertical thickness is 12 cm. The fracture in this last direction is triangular, being parallel to the leaf bases on each side, forming a sharp ridge of wood within. Twenty-four centimeters of the circumference is preserved and the distance from bottom to top over the curved surface is the same. (Locality: "Anne Arundel County.")

Pl. LXXXVII, Fig. V, 2, shows the Harrison fragment, W. C., B., No. 1486. It is a small fragment consisting entirely of the armor or bark from the side of a trunk of unknown dimensions. It is very well preserved, is of a brown color without and much lighter within, soft,

sandy, and light in weight relatively to its size. It is nearly square, three of the sides straight, the fourth broadly triangular. The straight sides measure, respectively, 80 mm., 85 mm., and 90 mm., and the length to the point of the triangle is 105 mm. The average thickness is about 4 cm. (Locality: Pl. LXXX, No. 74.)

Pl. LXXXVII, Fig. v, 3, is a view of the side and top of the R. T. Donaldson fragment, No. 2, W. C., B., No. 1656. It is a small fragment of a yellowish-brown color, 16 cm. long and 9 cm. wide by 8 cm. thick, from the interior of a trunk, showing on one edge a little of the medulla and wood, poorly preserved, and on the other some perforations and irregularities that evidently came from the surface but afford no idea of the shape of the leaf scars or nature of the buds. The holes may belong to the latter, being round, and at the bottom of some of them there is a partition dividing them into two. (Locality: Pl. LXXX, near No. 106.)

Pl. LXXXVII, Fig. v, 5, shows the Owens fragment, W. C., B., No. 3057, which is a small piece from the greatly compressed edge of a trunk, and consists almost entirely of the armor. It is of a light-brown color and rather soft, sandy consistency. It is 13 cm. long in a tangential direction and 5 cm. thick at the summit, but wedge shaped, so as to be only 3 cm. across the inner edge. The width is 9 cm., one face representing the exterior and the other a broken side parallel to the leaf bases. The scars are reduced by pressure and distortion to mere slits or angular perforations and can not be described or measured. (Locality: Pl. LXXX, No. 82.)

Pl. LXXXVII, Fig. v, 6, is a view of the R. P. Disney fragment, No. 3, W. C., B., No. 6350, one of the least important specimens, showing scarcely any structure. The exterior consists of a matted mass of distorted organs unevenly broken to form a harsh rough surface. One seems to be a large fruiting organ. It extends some distance internally, but the different zones do not show on the fractures which bound three sides. The dimensions are: Length, 11 cm.; width, 8 cm.; thickness, 8 cm. (Locality: Pl. LXXX, near No. 50.)

Pl. LXXXVII, Fig. v, 7, represents the R. T. Donaldson fragment, No. 7, W. C., B., No. 6349, which consists of a small piece of a vertically compressed trunk, perhaps coming from near the base, showing the

surface on one side and the cortical parenchyma with leaf strands on the other. A few of the scars are normal. The tangential length is 18 cm. and the vertical width 9 cm. The radial thickness is 6 cm. It is stained red by contact with paint clay. (Locality: Pl. LXXX, near No. 106.)

Pl. LXXXVII, Fig. v, 17, shows the D. O. Donaldson fragment, W. C., B., No. 1657, which has been broken from the outer portion of a small trunk showing a little of the armor and woody zone. It is a porous sandstone of a yellowish-brown color so much like that of the R. T. Donaldson fragment, No. 2, W. C., B., No. 1656, found at the same place, that there is a strong presumption that it belonged to the same trunk, although the two fragments do not fit each other in any way. The outside is stained pink, as if in contact with the paint clays. The specimen has a length in the direction of a cord of the circumference of 13 cm., a radial width of 8 cm., and a thickness of from 3 cm. to 6 cm., being somewhat wedge shaped. (Locality: Pl. LXXX, No. 107.)

Pl. LXXXVIII is the view taken on May 11, 1895, of the exposure on the east side of Deep Ditch, or the Link gorge, with the Link cycad, W. C., B., No. 1481, restored by Mr. Link himself to the place where he had seen it still projecting from the wall, before it fell to the bottom of the gorge where he found it and took it to his house.

Pl. LXXXIX, from a photograph made by the Woman's College of Baltimore, represents a group of cycads acquired by the college after the group shown on Pl. LXXXVII had been taken. Six of the specimens of this group belong to this species:

Pl. LXXXIX, Fig. II, 3, represents the Allen fragment, No. 1, M. G. S.-W. C., B., No. 9046, which comes from the side of a large trunk, near the base, extending inward to the medulla. It has two converging longitudinal radial fractures and a transverse fracture above. The inner side is bounded by a somewhat hollowed-out trough, lined with a thin layer of the coarse substance of the medulla. It is 20 cm. long, 9 cm. wide (tangentially), and 10 cm. thick (radially). The scars are pretty distinct and large for this species, but normal. The long curving leaf strands are well shown on the radial fractures. (Locality: Pl. LXXX, No. 101.)

Pl. LXXXIX, Fig. II, 4, shows most of one side of the R. T. Donaldson fragment, No. 14, M. G. S.-W. C., B., No. 9058, a small specimen, so covered with coarse sand firmly cemented to it that scarcely anything can be seen. It shows the external surface on one side and the medulla on the other, with two radial fractures through which the strands can be seen to pass. There are also two transverse fractures, on the upper one of which the division into armor, wood, and pith can be seen. The rock is hard and heavy. (Locality: Pl. LXXX, No. 106.)

Pl. LXXXIX, Fig. II, 7, shows considerable of the outer surface of the R. P. Disney fragment, No. 6, W. C., B., No. 6359, a good-sized, deeply pink-stained fragment, very poorly preserved, having a mashed mudlike appearance, but showing some very much distorted and exaggerated scars on the rounded surface. The inside is concave and shows distorted medullary rays. It is 24 cm. long (vertically), 15 cm. wide (tangentially), and 10 cm. thick (radially). (Locality: Pl. LXXX, No. 60.)

Pl. LXXXIX, Fig. III, 2, is a view of the broader side of the R. P. Disney fragment, No. 5, W. C., B., No. 6358, an almost shapeless fragment, showing just enough to make sure that it is a cycad. There is considerable surface, but no scars can be distinguished, the leaf bases and walls being all irregularly and unevenly broken and massed into a rough, harsh surface without structure. The inside is almost as obscure, and it is not certain what zone it represents. It may come from near the summit of a trunk. The measurements are 15 cm., 12 cm., and 10 cm., the last being from without inward. (Locality: Pl. LXXX, near No. 50.)

Pl. LXXXIX, Fig. III, 5, shows a little of one of the fracture planes of the R. T. Donaldson fragment, No. 17, M. G. S.-W. C., B., No. 9065, a small orange-stained fragment showing scarcely any structure, being mostly bounded by fracture surfaces. Over one small area a few much-worn scars are visible. It extends to the inner wall of the woody zone, where faint markings occur on the concave surface. The fractures show no structure. It is 12 cm. long, 10 cm. wide, and 7 cm. thick. (Locality: Pl. LXXX, No. 106.)

Pl. LXXXIX, Fig, III, 8, is a clear view of the outer side of the R. T. Donaldson fragment, No. 8, M. G. S.-W. C., B., No. 8319, which

is a small fragment, showing some poorly preserved scars on one side and the distinct striations of the medullary rays on the inner wall of the concave woody zone on the other. It has a transverse and a radial fracture. It is 13 cm. long, 8 cm. wide, and 6 cm. thick. (Locality: Pl. LXXX, No. 106.)

Pl. XC is from an excellent platinum print, made by Mr. T. W. Smillie, photographer of the National Museum, of the best preserved side of the Link trunk, W. C., B., No. 1481, and is by far the finest illustration we have of that important specimen.

The Link trunk consists of the upper portion, or perhaps nearly the whole, of a medium sized trunk considerably compressed laterally. There are some indications that the somewhat even cross section seen from below may have been near the true base. The summit is not depressed, neither is there a conical leaf bud, and the contour is nearly regular. Seen from the side the trunk presents a nearly semicircular outline. Viewed in the direction of its longer diameter it is somewhat conical, but there are depressions of different depths on both sides. The color is a light brown, drab, or fawn, the substance is soft and friable, and the specific gravity is low. The maximum height in an erect position is 25 cm., the major axis measured across the lower end is 39 cm., and the minor 22 cm. The compression, however, is least at this point, and the minimum would not exceed 12 cm., which is slightly increased just below the summit. The girth at the base is 97 cm., while at about the middle part it is 86 cm. (Locality: Pl. LXXX, No. 62a.)

Pl. XCI is a view from another of Mr. Smillie's platinum prints of one of the broad sides of the type specimen called the Helwig trunk, W. C., B., No. 3328. This is a nearly perfect trunk, which before compression was probably a true cone rounded off at the apex. The exterior is generally well preserved, but on one side all the partitions have been broken or worn off to the depth of 1 cm. or more, and the lower portion of the other side is still more deeply worn, so as to give a somewhat even surface flush with the remains of the leaf bases. The trunk is of a lively pinkish red color, rather soft and sandy in its composition, and of medium specific gravity.

The trunk stands 33 cm. high. The long diameter at the base is 31 cm. and this diminishes gradually to 23 cm. just below the abrupt contrac-

tion at the summit. The short diameter is nowhere more than 12 cm. and averages less than 10 cm. The maximum girth near the base is 73 cm. At the extreme summit it is only 41 cm. (Locality: Pl. LXXX, No. 62a.)

Pl. XCII gives two views of opposite sides of the Maryland Academy cycad No. 1, Fig. 2 showing also the summit, from a platinum print by Mr. Smillie.

This is the largest of the four cycads at the museum of the Maryland Academy of Sciences. It stands 35 cm. high, but being oblique at the base the shorter side measures only 25 cm. It is much flattened longitudinally, the longer axis at the base being 30 cm. and at the summit 22 cm. The minor axis is 19 cm. at the thickest part, near the middle, but the sides are irregular and the average is not over 15 cm. The girth is about 71 cm., except near the top, where it is 63 cm. The base is oblique in the direction of the major axis and the summit in that of the minor. It is thoroughly silicified and of a light color, reddish or pinkish and even dark in some places, much worn on all sides, rough and irregular on the surface. The leaf scars penetrate the armor at about a right angle to the axis of the trunk. (Locality: Pl. LXXX, No. 46.)

Cycadeoidea Tysoniana Ward.

Pl. LXXXVII, Figs. 1, 5; v, 4; Pl. XCIII.

1897. *Cycadeoidea Tysoniana* Ward: Proc. Biol. Soc. Washington, Vol. XI, p. 11.

Trunk medium sized or large, more or less compressed laterally; leaves slightly ascending; leaf scars arranged in spiral rows, 9 mm. high, 22 mm. wide, subrhombic, empty to some depth, petioles persistent at base, the vascular bundles arranged in one row near the exterior and a group near the center, often persisting after the decay of the remaining substance; ramentum walls thin, often with a layer of spongy substance in the middle, wrinkled on the edges; reproductive organs few and small; armor 5 cm. thick; libro-cambium zone sometimes distinct, 3 mm. thick; woody zone 6 cm. to 8 cm. thick; consisting of a broad, parenchymatous layer 4 to 6 cm. thick, and a narrow inner vascular zone 1 cm. thick, the latter usually between open tissue without and within, its inner wall strongly marked with longitudinal grooves; medulla distinct and homogeneous, light and porous.

This species differs from *C. marylandica* in the larger leaf scars, thinner walls, thicker armor, and the great paucity of reproductive organs, and from *C. McGeeana* in the normal shape of the trunk and its greater size. Since it was originally described from the type specimen, W. C., B., No. 1472, the only one then known, only one other, and this a mere fragment, W. C., B., No. 3352, the Giles fragment, has been found that could be referred to it.

A photograph of the type specimen, W. C., B., No. 1472, the R. T. Donaldson trunk, No. 1, called by him the "beef maw stone," was early made, showing the best preserved side and the hollowed-out apex (crow's nest), and this has appeared in two of the groups of Maryland Potomac cycads that have been published in the Annual Reports of the United States Geological Survey.[a]

It also occurs in the group photographed by the Woman's College, Pl. LXXXVII, Fig. 1, 5. These views are all too small to do it justice and it is shown less reduced on Pl. XCIII.

This is one of the largest and most perfect specimens in the collection, though obliquely truncated at both base and apex and deeply cavitous at both ends. It presents the general appearance of having been originally a leaning trunk, the angle of inclination having been nearly 40°.

The degree of mineralization is about normal, the color a dark gray-brown, and the specific gravity that of the average trunk. Its extreme length is nearly 45 cm., but only 30 cm. of the exterior is shown on one side and 22 cm. on the other. It is considerably compressed laterally, its major axis measuring 38 cm. and its minor axis 27 cm. It has a girth of 109 cm.

If the trunk is made to stand vertical, the leaves on the better preserved side are strongly deflexed, while those on the opposite side are acutely ascending, but placed at an angle of 40°; those on both sides are slightly and equally ascending. (Locality: Pl. LXXX, No. 81.)

Pl. LXXXVII, Fig. v, 4, shows the Giles fragment, W. C., B., No. 3352. This is a small fragment of quadrangular shape showing the external surface on one side and extending to the wood. The interior shows no structure, but the organs of the armor are very perfect and

[a] Sixteenth Ann. Rep., Pt. I, pl. c, fig. 2; and Nineteenth Ann. Rep., Pt. II, pl. lx, fig. 12.

agree in all respects with those of the large type specimen, W. C., B., No. 1472. This agreement extends to the phyllotaxy. The specimen is 11 cm. wide (tangentially), 10 cm. high (vertically), and 6 cm. thick (radially). (Locality: Pl. LXXX, No. 83.)

Cycadeoidea McGeeana Ward.

Pl. LXXXVII, Figs. III, 3, 10; IV, 15; V, 8, 9, 19, 20; Pl. LXXXIX, Figs. II, 1, 8; III, 4, 9, 10; Pl. XCIV.

1897. *Cycadeoidea McGeeana* Ward: Proc. Biol. Soc. Washington, Vol. XI, p. 12.

Trunks low and flat, with ample diameter, sometimes three times as thick as high, yellowish, brown, or nearly black, more or less porous and spongy, and of low specific gravity; leaves and spadices set nearly at right angles to the axis; leaf scars arranged somewhat definitely in quincunx order and disposed in spiral rows around the trunk, small and uniform in shape, subrhombic with the vertical angles obtuse, the lateral ones acute, narrow-elongate, 6 cm. to 10 cm. in vertical by 16 mm. to 20 mm. in lateral dimensions, averaging 8 mm. by 20 mm., usually empty by the disappearance of the leaf bases, at least to a considerable depth; ramentum walls thin, often less than 1 mm., with or without evident commissure, and with occasional punctations; axes of inflorescence few and scattering, sometimes projecting and filled with the substance of the spadix, sometimes cavitous from the decay of the essential organs, surrounded by obtusely triangular or somewhat crescent-shaped bract scars; armor 4 cm. to 5 cm. thick; liber and cambium sometimes distinguishable; woody zone usually divided into two or three rings; medulla large, porous.

A very distinct species of low and squat trunks, some of them having almost the form of a car wheel, only a very small part of which can be due to vertical compression. The external organs, however, closely resemble those of *C. Tysoniana*. It now embraces 13 specimens, an increase of 6 since 1897. They bear the numbers of the museum of the Woman's College of Baltimore, except a few of the last ones, which were obtained through the joint action of that college and the State Geological Survey of Maryland.

The following is the list, with numbers, local names, and weights:

	Weight in kilograms.
W. C., B., No. 1471, the M. A. Donaldson trunk ("basket stone")	4.65
W. C., B., Nos. 1659, 1659a, the Clark trunk ("insect nest")	6.01
W. C., B., No. 3055, the Deakins fragment ("barnacles")	1.92
W. C., B., No. 3068, the White fragment	1.25
W. C., B., No. 3323, the Luther Welsh fragment	1.80
W. C., B., No. 3325, the Inglehart fragment, No. 1	1.86
W. C., B., No. 3349, the W. P. Disney fragment	.94
M. G. S.-W. C., B., No. 9047, the R. T. Donaldson fragment, No. 9	.35
M. G. S.-W. C., B., No. 9054, the R. T. Donaldson fragment, No. 11	1.13
M. G. S.-W. C., B., No. 9055, the Marlowe fragment, No. 1	2.04
M. G. S.-W. C., B., No. 9057, the R. T. Donaldson fragment, No. 13	1.59
M. G. S.-W. C., B., No. 9060, the Travers fragment, No. 2	.62

All of the specimens are illustrated, though the less important fragments only appear in the large groups. Seven specimens are shown in the earlier and six in the later of the groups taken by the Woman's College.

Pl. LXXXVII, Fig. III, 3 represents the side of the Clark trunk, Nos. 1659 and 1659a, more fully illustrated and described below.

Pl. LXXXVII, Fig. III, 10 shows the flat top of the M. A. Donaldson trunk or "basket stone," W. C., B., No. 1471.

This is a nearly perfect, vertically much flattened trunk of nearly circular outline, but from one side of which a segment has been broken along a vertical plane, but quite irregularly. There is a depression at the base 13 cm. in diameter and 5 cm. deep. It is nearly flat across the top but very irregular and rough, caused by numerous depressions and protuberances. Considerably to one side of the center is a terminal bud, but it has suffered much from decay and now presents a jagged and fluted appearance. It is perforated with numerous tubes, some of which are cylindrical. They are the scars of the small leaves or perulæ of which the bud mainly consisted. Around its base in a circular depression are other larger ones. The specimen has been cut through the center by a vertical section at right angles to the fracture, and the surfaces polished. The section falls entirely on one side of the terminal bud.

The specimen is of a reddish color, well silicified and moderately hard and heavy. The diameter measured through the terminal bud and

parallel to the fracture is 27 cm. The partial diameter represented by the section is 20 cm. Its maximum height is 11 cm., but the vertical thickness in places is reduced to less than 5 cm. The girth is 76 cm., indicating a circumference for the whole trunk of about 85 cm. The polished section affords a clear view of the internal structure.

Pl. LXXXVII, Fig. IV, 15, gives a side view of the Inglehart fragment, No. 1, W. C., B., No. 3325. This specimen consists of a semicircular section of a small trunk, taken probably from above the middle. The vertical fracture is a nearly even plane through about the center of the axis, but leaving a hollow trough below, formerly occupied by the medulla. The lower transverse fracture is also even and horizontal. The upper fracture has carried away a small part of the apex, and there is besides an eroded cavity. The trunk was 12 cm. high and 16 cm. in diameter. (Locality: Pl. LXXX, No. 96.)

Pl. LXXXVII, Fig. V, 8, called the Deakins fragment, W. C., B., No. 3055, is a small piece from one of the thin edges of a greatly laterally compressed trunk, probably of small size and perhaps representing most of its length, but showing neither base nor summit. The fracture runs out above where the summit began to round off. At the lower end it is very irregular, reaching farther down at the outer edge and on one side. The vertical fracture is moderately even and mostly parallel to the axis. The specimen is reduced to a mere slab, and probably includes much less than half of the trunk, but the organs are all present over the surface on both sides. There is a sort of crook or bend near the middle, and in the angle thus made on one side there is a nearly circular depression 2 cm. deep, the result of decay. The color is very dark, almost black, on one side. The rock is moderately firm and hard, but not heavy. The length is 25 cm., the width 12 cm., and the thickness 7 cm. (Locality: Pl. LXXX, No. 128.)

Pl. LXXXVII, Fig. V, 9, shows a little of the surface of the Luther Welsh fragment, W. C., B., No. 3323, which is a small slab broken from the side of a small trunk near the top. The trunk was flattened laterally, and the main fracture is a tangential plane starting from the narrow side or edge, which would have come out on the broad side but for a second minor fracture at right angles to it which removed a portion of the thinner edge. Both fractures are even and straight, the principal one parallel to

the axis, the other sloping outward from above. The rock is of a dark-ash color, lighter within. It is rather hard and heavy and quite compact. The length (height) is 16 cm. and the width about 15 cm., while the maximum thickness is 6 cm. (Locality: Pl. LXXX, near No. 80.)

Pl. LXXXVII, Fig. v, 19, is a side view of the W. P. Disney fragment, W. C., B., No. 3349, which is so much worn that it is difficult to make out its relations. It is certainly cycadean and belongs mostly to the armor. It is irregularly circular in shape, 11 cm. to 13 cm. in diameter and 5 cm. to 6 cm. thick. The inner surface is spongy and probably reaches some distance into the wood. The edges show the leaf bases and spadices. Faint scars of the petioles are visible on the worn interior. Those of the flowering axes are much more distinct and exhibit the usual characters. (Locality: Pl. LXXX, near No. 50.)

Pl. LXXXVII, Fig. v, 20, represents the White fragment, W. C., B., No. 3068. It consists of a small piece, probably from from a nearly circular trunk of moderate size that was much vertically compressed, but doubtless originally very low and squat. It extends from base to summit, but only represents one side, being an imperfectly wedge-shaped segment formed by two irregularly vertical fracture planes somewhat as a cake is cut. The outer parts are dark brown, while the inner ones are light colored, reddish-white with bright streaks of white. The substance is light and porous or soft sandy and more or less friable, but in places it becomes hard and partially opalized. Its longest measurement, which is in a transverse direction, is 14 cm. Measured tangentially it is 8 cm., while its vertical thickness is 10 cm. (Locality: Pl. LXXX, No. 71.)

Pl. LXXXIX, Fig. II, 1, shows the thin outer edge of the R. T. Donaldson fragment, No. 9, M. G. S.-W. C., B., No. 9047, which consists of a thin wedge from the side of a trunk, penetrating from the surface to the center of the medulla. It has a surface of only 4 cm. (vertical) by 13 cm. (arc), but over this surface the leaf scars are beautifully shown, and they are the smallest thus far observed, being only 10 mm. to 15 mm. wide by 4 mm. to 7 mm. high and very regularly arranged. The walls are rather too thick for *C. McGeeana* and it is very probable that if the entire trunk had been found it would have proved to be a new species. (Locality: Pl. LXXX, No. 106.)

Pl. LXXXIX, Fig. II, 8, representing the R. T. Donaldson fragment, No. 13, M. G. S.-W. C., B., No. 9057, is a flat, vertically compressed frag-

ment resembling W. C., B., No. 1659, and stained the same color as that, but in a bad state of preservation. The form of the scars can not be determined. There is also a transverse fracture, which renders the vertical thickness uncertain. A little over half of the trunk is present, the irregular longitudinal tangential fracture passing one side of the middle. The diameter is 19 cm., the radial distance at right angles to this 11 cm., and the present vertical thickness 7 cm. (Locality: Pl. LXXX, No. 106.)

Pl. LXXXIX, Fig. III, 4, shows the outer surface of the Travers fragment, No. 2, M. G. S.-W. C., B., No. 9060, a small, much worn piece of the armor of a trunk of unknown size, of dark color and low specific gravity. This small area, however, 9 cm. by 11 cm., shows very clearly both leaf scars and reproductive organs. It is simply a piece of bark, convex on the outer and concave on the inner surface, and 3 cm. to 4 cm. thick. (Locality: Pl. LXXX, No. 69.)

Pl. LXXXIX, Fig. III, 9, gives a view of the outer surface of the Marlowe fragment, No. 1, M. G. S.-W. C., B., No. 9055, which is a rather large piece from the side of a trunk, probably at the base, bounded by two longitudinal radial fractures and one transverse fracture, and extending to the middle of the medulla. The surface is well preserved, and the fractures show the internal structure. It is 15 cm. long, 12 cm. wide above, and 8 cm. below, and 9 cm. thick. (Locality: Pl. LXXX, No. 100.)

Pl. LXXXIX, Fig. III, 10, shows the broad side of the R. T. Donaldson fragment, No. 11, M. G. S.-W. C., B., No. 9054, a light-reddish stained fragment, probably from near the base of a trunk, showing much worn scars on the convex outer surface and the bases of the strands on the concave inner surface. It is 16 cm. long (high), 12 cm. wide (tangentially), and 6 cm. thick, probably including the outer ring of wood. (Locality: Pl. LXXX, No. 106.)

Pl. XCIV, from a fine platinum print made by Mr. Smillie, shows as clearly as a picture can show the leading characters of the species as embodied in the next most perfect specimen, W.C., B., Nos. 1659 and 1659a, which were simply broken apart but fit each other perfectly. The view is from the base, but, as in the specimen last described, the leaf scars are shown only below the equatorial zone. The two pieces constitute

about two-thirds of a very low, flat trunk, complete at both base and summit, which, although it has doubtless suffered much from vertical compression, must have been originally exceedingly short in proportion to its diameter. There is a large and rather deep depression at the base, with a central elevation, all of which seems to have existed before fossilization. There is also a broad, shallow depression at the summit and the smaller piece has lost something here from fracture. These two depressions reduce the specimen to the shape of a car wheel. The whole surface is stained a light ocher by the red-paint clay in which it had lain, but it is white within. The rock is rather soft and light. The maximum vertical thickness is only 12 cm., but at the thinnest place in the interior it is less than 4 cm. The diameter is 36 cm. and the specimen is nearly circular in cross section. This would give the trunk a girth of 113 cm., and the actual girth of the parts preserved is about 1 meter. (Locality: Pl. LXXX, near No. 75).

Cycadeoidea Fontaineana Ward.

Pl. LXXXVI; Pl. LXXXVII, Figs. I, 1; III, 2, 6, 8; IV, 1, 7, 9; V, 1, 10, 11, 13, 14, 16, 18, 21; Pl. LXXXIX, Figs. I, 1; III, 1, 3, 6, 7, 11; Pl. XCV; Pl. XCVI; Pl. XCVII; Pl. XCVIII.

1897. *Cycadeoidea Fontaineana* Ward: Proc. Biol. Soc. Washington, Vol. XI, p. 13.

Trunks small and low, usually much compressed or flattened vertically, light brown to whitish in color, often spongy or porous, and of low specific gravity; leaves and spadices set nearly at right angles to the axis; leaf scars not obviously arranged in spiral rows or imperfectly so arranged, variable and irregular in shape, usually with four angles and four curved sides, often in the form of a cross, rarely subrhombic, small, 8 mm. to 12 mm. in vertical and 14 mm. to 25 mm. in lateral measurement, averaging 10 mm. by 19 mm; ramentum walls thick, 4 mm. to 10 mm., usually without commissure or punctations; leaf bases rarely present; when so, spongy or porous, without visible bundles; terminal bud 6 cm. high, 65 mm. broad at the downwardly convex base, definitely bounded below, symmetrically conical above, consisting of a mass of densely matted bracts imbricated along a central axis; reproductive organs few and imperfectly defined, usually cavitous in the center and sometimes surrounded by irregular-shaped bract scars; armor rather

thin, 2 cm. to 4 cm.; liber and cambium obscure; woody axis divided into several rings, sometimes consisting of a loose, open structure separated by thin, firm plates, the inner face next the medulla definitely marked by the remains of vessels and medullary rays; medulla large, marked on the external surface by thin longitudinal ridges or lamellæ varying from 1 cm. to 3 cm. in length, the ends overlapping adjacent ones (Cycadeomyelon saporta), internal parts coarse and porous or somewhat chambered.

This species resembles *Cycadeoidea McGeeana* in the general form of the trunks, but the external organs are very different, the most striking distinction being the very thick walls. It now embraces 27 specimens, 12 of which have come to light since it was originally described in 1897. The two smaller specimens in the museum of the Maryland Academy of Sciences have been somewhat doubtfully referred to this species. They are fragments and show so few characters that their specific relations are obscure.

These are not figured and may therefore be briefly described here. The first of these, called the Maryland Academy cycad No. 3, is the third in size of the four specimens in the museum of the Maryland Academy of Sciences and is a fragment from one side of a small trunk. It includes nearly or quite half of the external surface, unless it should represent the thin side or edge of an elliptical trunk—which can not be certainly ascertained, but seems probable, the specimen including one of the narrow sides and part of one of the broad ones. It is of a dark reddish-brown color, lighter within, rather soft and porous, and of low specific gravity. It is 21 cm. in length (height) and 14 cm. in diameter, and is 6 cm. to 9 cm. in radial thickness.

The other, called the Maryland Academy cycad No. 4, is the smallest of the four specimens in the museum of the Maryland Academy. It is a mere cap, broken by a nearly horizontal cleavage from the top of a large trunk, and this is in turn broken along a vertical plane a little to one side of the center. There is a distinct terminal bud, and this is wholly included in the specimen. The upper surface is badly worn and shows nothing but a warty, uneven structure, but the boss representing the terminal bud is set in a slight depression. The bud is decayed at the base so as to be visible from below. The broken surfaces all show

the leaf bases, ramentum walls, fibers, etc. The rock is of a red color, as if stained with the paint in which it was doubtless long embedded. It is dark and heavy and highly mineralized, especially on the interior parts, which have a crystalline surface with numerous frost-like projections. The specimen is 17 cm. in diameter. The partial diameter measured from the circumference through the center to the vertical fracture is 14 cm., which shows that this would have been the major axis of a somewhat elliptical cross section. The vertical thickness is between 6 cm. and 7 cm.

Two other specimens referred to this species are not figured and may be mentioned here. One of these is the R. T. Donaldson fragment, No. 5, W. C., B., No. 3327, a very small piece, measuring 8 cm. in tangential, 8 cm. in radial, and 6 cm. in vertical direction. It consists chiefly of a piece of the wood, and could not have been recognized as a cycad but for a small portion of the armor attached to one side containing one leaf scar and one fruiting axis.

The other is the R. W. Clark fragment, W. C., B., No. 3350, a very small piece of a trunk of unknown size, showing a little of the external surface and extending in a wedge-shaped manner a short distance into the axis. It is rather light colored, with rust streaks, and soft sandy in structure. It is 8 cm. in a tangential direction and 4 cm. in a direction parallel to the axis of the trunk. Its radial thickness is a little over 6 cm. The surface shows a few imperfect leaf scars. Two projecting reproductive organs are present on the small area exposed.

The reference of all these fragments to *Cycadeoidea Fontaineana* is, of course, more or less doubtful. The South Carolina College cycad clearly belongs to this species.

The following is a list of the numbers, with the names assigned and the weights:

	Weight in kilograms.
Maryland Academy Cycad, No. 3	2.53
Maryland Academy Cycad, No. 4	1.72
South Carolina College Cycad	5.56
W. C., B., No. 1467, the Griffith trunk	8.00
W. C., B., No. 1470, the Noah Donaldson trunk	3.18
W. C., B., No. 1473, the R. T. Donaldson fragment, No. 1	.45
W. C., B., No. 1485, the Cronmiller fragment	1.42

	Weight in kilograms.
W. C., B., No. 1488, the Riddle fragment	7.83
W. C., B., No. 1489, the Magruder fragment	3.41
W. C., B., No. 1658, the Comegys fragment	1.92
W. C., B., No. 3046, the Turner trunk ("chicken trough")	9.64
W. C., B., No. 3122, the Cole fragment	.23
W. C., B., No. 3326, the R. T. Donaldson fragment, No. 4	.61
W. C., B., No. 3327, the R. T. Donaldson fragment, No. 5	.31
W. C., B., No. 3346, the Emmons fragment	3.20
W. C., B., No. 3347, the Odensoss fragment	1.80
W. C., B., No. 3350, the R. W. Clark fragment	.17
W. C., B., No. 6346, the Anderson fragment	1.59
W. C., B., No. 6347, the Inglehart fragment, No. 2	3.06
W. C., B., No. 6348, the R. P. Disney fragment, No. 2	1.08
W. C., B., No. 6352, the R. P. Disney trunk, No. 2	3.57
M. G. S.-W. C., B., No. 9051, the Whitehead trunk, No. 2	9.30
M. G. S.-W. C., B., No. 9053, the R. T. Donaldson fragment, No. 10	.51
M. G. S.-W. C., B., No. 9056, the R. T. Donaldson fragment No. 12	.15
M. G. S.-W. C., B., No. 9061, the Marlowe fragment, No. 3	.14
M. G. S.-W. C., B., No. 9062, the R. T. Donaldson fragment, No 15	.58
M. G. S.-W. C., B., No. 9064, the R. T. Donaldson fragment, No. 16	.45

Pl. LXXXVI shows the outer surface of the South Carolina College cycad sent me by Mr. Glenn, an account of which was given in the historical part of this paper (see p. 414.) It is a triangular fragment from one side of a rather large, short, subconical, laterally and perhaps vertically compressed trunk. It evidently comes from near the base, but no part of the true base is preserved. It extends inward to the inner wall of the woody zone. The small end of the wedge is downward and the specimen broadens upward. The radial fractures are nearly even; the upper fracture passes obliquely upward and outward, becoming horizontal near the surface; the basal fracture is a small, irregular area. The specimen is in a fair state of preservation, of a reddish-brown color, rather soft, and nearly uniform consistency and low specific gravity. The length or height parallel to the axis is 22 cm. The maximum tangential width (near the upper end) is 25 cm. and the minimum at the lower end 6 cm. These measurements are on the outer surface. The greatest distance across the concave inner surface is 12 cm. The thickness measured on the radial frac-

tures is about 9 cm. One of these is oblique and shows over 10 cm. The greatest arc of the circumference is 25 cm. The specimen is also very convex vertically, and this arc measures 26 cm.

The leaf scars of *C. Fontaineana* are always very irregular, and this specimen presents the anomaly of having the sharper vertical angle as often above as below. This at first made it doubtful what was the true position of the trunk. But the vascular strands, clearly seen on both the radial fractures, is conclusive as to the true position. These strands rise at a sharp angle from the fibrous zone, pass at a much wider angle nearly straight through the cortical parenchyma, and then curve gracefully outward into the leaf bases, sometimes bending somewhat downward where these are slightly descending. The inner wall of the wood, which was in contact with the medulla, shows over a concave area of 10 cm. by 14 cm. alternating rows of elliptical scars, 5 mm. by 15 mm. in diameter, of the medullary rays, the upward inclination of which is distinct.

Pl. LXXXVII, Fig. I, 1 is an end and top view of the Turner trunk, W. C., B., No. 3046, more fully shown on other plates.

Pl. LXXXVII, Fig. III, 2, is a side and top view of the Griffith trunk, W. C., B., No. 1467, another principal type of the species. The terminal bud can be seen in this view, but the specimen had been sectioned through the center of the bud before this group was photographed.

Pl. LXXXVII, Fig. III, 6, shows the Noah Donaldson trunk, W. C., B., No. 1470, but not to good advantage.

Pl. LXXXVII, Fig. III, 8, is a very good side view of the Riddle fragment, W. C., B., No. 1488. This specimen probably contains three-quarters of the entire trunk. It seems to extend from at or very near the true base to within a very short distance of the summit. It is flattened laterally to a thin slab, and a piece of considerable size is broken away along an even vertical plane from one of the edges. A large irregular piece has also disappeared from one side, reaching inward to the middle and extending from the top downward to below the middle on one edge but much less on the other. It is of a light-drab or fawn color, with rust stains at some places, firmly silicified and moderately hard and heavy. It is 24 cm. high and has a maximum width of 26 cm. The missing piece added to this would probably give a width

(major axis) of 30 cm. It rounds off rapidly upward from near the base, so that the width at the summit is only 15 cm. The thickness (minor axis) is about 10 cm. on the outer edge and 9 cm. across the fractured one. On the broken side the surface parts rise only 5 cm. on the lower side, which is increased to 15 cm. at the opposite side of the oblique fracture. (Locality: Pl. LXXX, near No. 102.)

Pl. LXXXVII, Fig. IV, 1, is a side view of the Comegys fragment, W. C., B., No. 1658, which probably came from near the summit of a laterally compressed trunk of small size embracing part of one of the broad sides and one of the narrow ones, the hollow interior corresponding to the curved external surface. The color is drab on the outside and buff within. The rock is light and rather sandy, but not friable. The maximum height is 20 cm., but one side is broken very obliquely, so as to make the basal portion narrow. The greatest width is 17 cm., which is reduced below to 7 cm., and rounded off at the top. The radial thickness is about 5 cm. (Locality: Pl. LXXX, near No. 75.)

Pl. LXXXVII, Fig. IV, 7, shows the summit, with terminal bud, of the R. P. Disney trunk, No. 2, W. C., B., No. 6352, more fully illustrated below.

Pl. LXXXVII, Fig. IV, 9, shows a side and fractured surface of the R. P. Disney fragment, No. 2, W. C., B., No. 6348, which is only a small piece of medulla, 6 cm. square and 1 cm. thick, rounded at one end and forming a little slab, but showing the medullary ray scars very prettily on the convex surface. It looks as though it might have formed a part of the trunk No. 1470. (Locality: Pl. LXXX, near No. 50.)

Pl. LXXXVII, Fig. V, 1, represents the Cole fragment, W. C., B., No. 3122, a very small piece from the side of a trunk of unknown size. It is of a light color, sandy texture, and low specific gravity, and is about 8 cm. square and 6 cm. thick, of which the part belonging to the armor is slightly more than 4 cm. thick, the rest consisting of a conical piece of the wood, which is perforated by the tubes of decayed vessels. (Locality: Pl. LXXX, No. 54.)

Pl. LXXXVII, Fig. V, 10, shows only some fractured surfaces of the Inglehart fragment, No. 2, W. C., B., No. 6347. This specimen seems to represent more than half of a small, dark-colored trunk of the type of W. C., B., No. 1658. It is somewhat laterally compressed and

the vertical tangential fracture was parallel to the minor axis. It is 18 cm. high and the small diameter is 13 cm. In the direction of the long diameter it now measures the same, indicating that it was 20 cm. Neither the base nor the summit is perfect. The medulla is wanting for the lower half of its length, leaving a hollow cavity. (Locality: Pl. LXXX, No. 99.)

Pl. LXXXVII, Fig. v, 11, shows the exterior of the Magruder fragment, W. C., B., No. 1489, to be treated more fully further on.

Pl. LXXXVII, Fig. v, 13, is a fairly good view of the Emmons fragment, W. C., B., No. 3346. It comes from a trunk that was probably large, apparently broken from one side near the base, and having a concave interior corresponding to the convex surface. It is broader at the irregularly broken upper end, the contracted base appearing to be nearly normal. One side is thicker than the other and probably represents the narrow side of an elliptical trunk. It is of a very light color, almost white in places, and chalky white where freshly bruised. It is also very light and spongy in structure, resembling bone, and friable. It is 18 cm. high and has a maximum tangential width of 21 cm. (Locality: Pl. LXXX, No. 62b.)

Pl. LXXXVII, Fig. v, 14, shows the Odensoss fragment, W. C., B., No. 3347. This fragment seems to belong to a small trunk which was considerably compressed laterally, and to represent the upper part of one of the narrow sides. It is nearly half of a cone, broken irregularly at the top and somewhat obliquely at the bottom. The missing central parts have left a hollow for the entire length. It is of a very light color and ashy appearance, rather soft, and of low specific gravity. Its maximum height is 16 cm., but on one side it is only 11 cm. It is 14 cm. in diameter below and 8 cm. at the top. The radial thickness varies from less than 5 cm. to over 7 cm. (Locality: Pl. LXXX, No. 31.)

Pl. LXXXVII, Fig. v, 16, is a somewhat unsatisfactory view of the Anderson fragment, W. C., B., No. 6346, which will be fully treated below.

Pl. LXXXVII, Fig. v, 18, is the only illustration we have of the R. T. Donaldson fragment, No. 4, W. C., B., No. 3326. It is a very small fragment, probably from a small trunk. It has the appearance of a piece of a trunk only 9 cm. in diameter, but is more probably from the thin edge of a laterally much compressed trunk.

The specimen is much lighter colored than most of those from the iron-ore beds. It is thoroughly silicified and moderately hard and heavy. It is 15 cm. long (high) and 5 cm. in radial direction. (Locality: Pl. LXXX, No. 106.)

Pl. LXXXVII, Fig. v, 21, represents the R. T. Donaldson fragment, No. 1, W. C., B., No. 1473. This is a small fragment of what may properly be called bark—that is, liber and armor. It is 16 cm. long, 65 mm. wide, and 4 cm. thick, and triangular in shape. The markings on the inner surface are distinct and consist of elevated and somewhat rhombic scars terminating in a prolonged ridge tapering to a point. (Locality: Pl. LXXX, near No. 106.)

Pl. LXXXIX, Fig. I, 1, shows the Whitehead trunk, No. 2, M. G. S.-W. C., B., No. 9051, lying on its side and exhibiting the exposed medulla and adherent armor, the base being at the right. It embraces considerable of the lower part of a fair-sized trunk of doubtful affinity, somewhat resembling W. C., B., No. 1488, but harder and heavier. One side is eroded or decayed to the medulla, and both the base and summit are wanting, but the former could not have been far away. It is 23 cm. high, oblique in the same direction below and above, 23 cm. in larger and 15 cm. in smaller diameter, this latter not complete. It has a girth of 64 cm. (Locality: Pl. LXXX, near No. 105.)

Pl. LXXXIX, Fig. III, 1, is a view of the R. T. Donaldson fragment, No. 10, M. G. S.-W. C., B., No. 9053. It is 10 cm. long, 8 cm. wide, and 5 cm. thick, and shows a few scars and reproductive organs. (Locality: Pl. LXXX, No. 106.)

Pl. LXXXIX, Fig. III, 3, is a surface view of the Marlowe fragment, No. 3, M. G. S.-W. C., B., No. 9061. It has an area of surface 6 cm. by 10 cm., showing scars of leaves and fruits, and extends 6 cm. inward to the woody zone. (Locality: Pl. LXXX, No. 100.)

Pl. LXXXIX, Fig. III, 6 shows faintly, because somewhat out of focus, the side of the R. T. Donaldson fragment, No. 15, M. G. S.-W. C., B., No. 9062. It consists of a small piece, chiefly of armor, 11 cm. high, 12 cm. wide, and 4 cm. thick, and having the same kind of matted and obscured surface as W. C., B., No. 3347, which it also resembles in other respects. (Locality: Pl. LXXX, No. 106.)

Pl. LXXXIX, Fig. III, 7 represents the R. T. Donaldson fragment, No. 16, M. G. S.-W. C., B., No. 9064, a peculiar spongy-looking fragment,

17 cm. long, 6 cm. wide, and 4 cm. thick, somewhat resembling W. C., B., No. 3347, but with the abnormal features of that specimen exaggerated. (Locality: Pl. LXXX, No. 106.)

Pl. LXXXIX, Fig. III, 11 is a view of the R. T. Donaldson fragment, No. 12, M. G. S.-W. C., B., No. 9056, a very small fragment of the type of W. C., B., No. 1470. It is 7 cm. long, 6 cm. wide, and 3 cm. thick. (Locality: Pl. LXXX, No. 106.)

Pl. XCV is a view from above of the Turner trunk, W. C., B., No. 3046, showing the deep partitioned cavity ("crow's nest") at the summit, which constituted the "chicken trough." This is one of the principal types of *C. Fontaineana*. It is a practically complete trunk of low stature and narrow ovate cross section, much wider above than below, with the whole upper part hollowed out deeply, so that it was used by its owner as a chicken trough. The rapid diminution downward gives it somewhat the shape of a boat. There is also a hollow depression at the base, but of much smaller size than that of the summit. It is of a dull-brown color, lighter in places, or shading to reddish rust color. It is well silicified and moderately hard. The maximum height is 20 cm., but the lowest side is only 16 cm. The long diameter is 32 cm. and the short one 17 cm. at the largest part. At the base these measurements are reduced to 28 cm. and 12 cm., respectively. The average girth is 80 cm. The cavity at the summit is 9 cm. deep, with an irregular bottom showing small openings several centimeters deep. It is 19 cm. long and 12 cm. wide. The hollow at the base is 3 cm. deep, 17 cm. long, and 8 cm. wide. The cortex rounds in at the summit, and the organs of the armor are here massed together. There may have been some vertical pressure. (Locality: Pl. LXXX, No. 93.)

Pl. XCVI shows in great detail the polished section of the Griffith trunk, W. C., B., No. 1467, that was cut through the center of the terminal bud and short axis, exposing the internal organs and tissues. This was the original type of the species, and the general form, the characters of the exterior, the setting of the terminal bud, etc., are shown in Fig. 3 of Pl. XCVII and in the still further reduced group figures above enumerated.

The specimen consists of considerably over half of a small trunk which is low and squat, as if greatly compressed vertically. The upper portion is entire and elliptical in outline. The longer diameter is 28 cm.

taken through the axis, but on account of eccentricity it is 33 cm. where greatest. The shorter diameter is 20 cm. The greatest vertical measurement obtainable is 13 cm., but the general vertical thickness is about 11 cm. It is impossible to say how much the missing portion would have added to these measurements. The shape is extremely irregular, and what is to all appearances the true summit containing a perfect terminal bud has an axis which is nearly at right angles to the axis indicated by the medulla. The specimen is of a reddish-brown color, lighter than the average. The terminal bud is 6 cm. high, definitely bounded at its base, which is 65 mm. in diameter and regularly convex downward, so that if removed a perfect "crow's nest" would remain. The terminal bud seems to consist of a mass of densely matted bracts imbricated over one another along a central axis, i. e., growing shorter and shorter from without inward. The specimen has been cut through the center of the axis of the terminal bud, the section passing through the armor and general axis, thus exposing the internal structure. The cut faces have been polished and a photograph made. From this cut face the thickness of the armor is seen to be about 4 cm. The leaf scars are much compressed and pass down through the armor in the form of fine lines. The armor rests upon a loose heterogeneous layer 15 mm. thick. This layer does not occur beneath the terminal bud, which rests on a triangular mass of fine homogeneous tissue 35 mm. thick and extending to the medulla, which is much flattened, about 32 mm. thick, and porous. (Locality: Pl. LXXX, near No. 68.)

Pl. XCVII, Fig. 1 represents the Noah Donaldson trunk, W. C., B., No. 1470. It is a portion of the medulla of a large, much laterally compressed trunk with a small piece of the external part attached to the narrow edge. The medulla itself is decayed in the middle and irregularly broken or eroded away above and below with an opening on one side. The whole is very light colored, porous, and sandy, but rather firm. The total length is 31 cm. and the maximum width 18 cm. The thickness is 9 cm.

The armor is about 2 cm. thick, and no definite line can be drawn between it and the mass of fibers that mostly makes up the woody cylinder which it incloses, and which is also about 2 cm. thick. This latter so clasps one of the edges of the pith for a length of 21 cm. as to leave it

exposed along both sides and for 10 cm. at the lower end. This makes it possible to look along the junction and see just how the medullary rays pass into the outer parts. Thin longitudinal ridges or lamellæ varying from 1 cm. to 3 cm. in length rise from the surface of the medulla and penetrate the woody zone. These ridges are not exactly parallel, but are slightly oblique, so that their ends pass one another, giving the general surface a somewhat reticulate appearance. They are coarser and sharper than those represented in Saporta's figure of *Cycadeomyelon hettangensis* Sap. (Pl. Jur., pl. cxix, fig. 5). The portion of *Bucklandia Milleri* Carr, (loc. cit., pl. lv., fig. 1), from which the outer parts are removed, approach it more closely, but the nearest figure to it known to me is that of *Omphalomela scabra* Germar (Palaeontographica, Vol. I, pl. iii). The bundles can also be seen passing out very obliquely and becoming nearly vertical at the summit. They are chiefly represented by large cylindrical tubes. (Locality: Pl. LXXX, near No. 106.)

Pl. XCVII, Fig. 2 shows the Cronmiller fragment, W. C., B., No. 1485. This is a piece of the armor, only 26 cm. long, of one edge of a very much laterally compressed trunk, and may be compared with similar parts of W. C., B., No. 1470, as Mr. Bibbins has done. It would seem to have undergone some compression after the axis had disappeared, as it is narrower next the axis than farther out. (Locality: Pl. LXXX, No. 69a.)

Pl. XCVII, Fig. 3 is the best view made of the Griffith trunk, W. C., B., No. 1467, already described, prior to sectioning, and shows one side and the summit with its terminal bud.

Pl. XCVII, Fig. 4 is an interior view of the Magruder fragment, W. C., B., No. 1489, of which the outer surface is represented on Pl. LXXXVII, Fig. v, 11. This is a segment from the outer portion of a small trunk extending less than halfway round, so preserved that a cross section would be crescent shaped. It extends to the extreme base, and the central portion, which is higher than the rest, probably reaches nearly to the summit. It is of a light-reddish color, soft sandy consistency, and low specific gravity. The maximum height is 17 cm., which is reduced to 9 cm. at both ends of the segment. The diameter of the trunk, which seems to have been nearly cylindrical, was 21 cm. The partial girth is 40 cm. The diameter of the hollow interior is 11 cm. The radial thickness of this segment varies from 6 cm. to 8 cm. The

woody zone, or portion of it here preserved, consisting of one homogeneous ring of a very porous structure, the cortical parenchyma, is nearly 6 cm. thick, as clearly shown at the base. The hollow interior representing the inner wall of this ring of wood is studded with the projecting tips of definite fluted bodies representing the sheaths of the fibrovascular bundles. These are somewhat pointed below, pass upward, and plunge outward into the substance of the wood, broadening as they advance. In some places these may be traced nearly 5 cm. The layer into which they pass is of a very spongy consistence. Near the base, where only the ends are exposed, these tubes appear as semilunar, crescent-shaped, or horseshoe-shaped scars, all of which have an inner curved line in intaglio parallel to the outer contour.

This small fragment shows most of the characteristics of fossil cycads, and being light and easily transported it was made by Mr. Bibbins to serve an important purpose. He placed it in his carriage when going about the country in search of cycads and showed it to the inhabitants as illustrating what he meant. Often on seeing it a miner or farmer would recognize it as similar to something he had, and this would lead to the discovery of additional specimens. (Locality: Pl. LXXX, near No. 102.)

Pl. XCVII, Fig. 5 shows the interior of the Anderson fragment, W. C., B., No. 6346. It is a small, much-worn fragment, so closely resembling W. C., B., No. 1470 as to suggest that they may be parts of the same trunk. It is 18 cm. long, 12 cm. wide, and 9 cm. thick, but very irregular in shape, showing a little surface with the scars worn down, and large areas over which the erosion has penetrated to the cortical parenchyma, exposing the course of the large leaf strands. Considerable of the medulla remains attached to the upper end. (Locality: Pl. LXXX, No. 108.)

Pl. XCVIII, Figs. 1 and 2 are views of the top and base, respectively, of the R. P. Disney trunk, No. 2, W. C., B., No. 6352. This specimen strongly recalls the type, W. C., B., No. 1467, and has a terminal bud equal to that in its perfection. It shows much better the apical leaves forming the bud. The specimen, however, is smaller, being 17 cm. by 23 cm. in diameter, 60 cm. in girth, and 11 cm. high, including the terminal bud, which is 3 cm. high. The leaf scars are not well shown, being completely massed together by vertical pressure. The base shows the different zones fairly well. (Locality: Pl. LXXX, No. 59a.)

Cycadeoidea Goucheriana Ward.

Pl. LXXXVII, Fig. 1, 3; Pl. LXXXIX, Fig. 1, 3; Pl. XCIX.

1897. *Cycadeoidea Goucheriana* Ward: Proc. Biol. Soc. Washington, Vol. XI, p. 14.

Trunks large, cylindrico-conical with elliptical cross section, 30 cm. to 50 cm. high, 25 cm. to 50 cm. in diameter, light colored and of low specific gravity, somewhat chalky and friable; lower leaves somewhat deflexed, upper ones ascending the line between the two definite and encircling the trunk near the middle; leaf scars arranged in two sets of spiral rows, both having nearly the same angle to the axis, 45° or greater; scars variable in size and shape, chiefly subrhombic to nearly triangular with curved or fluted sides, inner wall of the tubes marked by a raised line around it; scars averaging 11 mm. in vertical and 23 mm. in lateral measurement; leaf bases usually absent or only adhering to the bottom of the scars; ramentum walls thick, more or less divided into irregular laminæ or scales with fissures between them, their outer edges ragged; reproductive organs numerous, well marked, irregularly scattered over the surface, most abundant at the narrower sides, usually cavitous in the center, sometimes solid and protruding, surrounded by concentrically arranged, crescent-shaped bract scars, sometimes well exposed and clearly distinguishable into spadix and involucre, the scales of the latter imbricated, the entire organ conical with the apex toward the axis of the trunk; armor 3 cm. to 5 cm. thick, separated from the wood by a definite line; woody zone 4 cm. thick, consisting of an outer parenchymatous ring 3 cm. thick, a thin ring of loose open structure, and two thin plates separated by another ring of coarse cells divided by radial partitions, the inner walls of both plates marked with scars of the medullary rays, the pattern different in the two cases, the scars on the inner plate 13 mm. long, those on the outer longer and tapering upward; medulla large, elliptical, tapering upward, of a coarse homogeneous structure.

The original type, the Wilson trunk, W. C., B., No. 1479, with the small piece that became detached from its interior after its discovery and was numbered 1479a, remained unique until 1901, when Mr. Charles Dearstine contributed the fine fragment, M. G. S.-W. C., B., No. 9049, described below. This specimen adds considerable to our knowledge of the species, especially of the base, which is decayed away in the other.

Views of both the specimens appear in the different groups and show their relative size and character, and the type is shown in Pl. XCIX.

Pl. LXXXVII, Fig. 1, 3 represents the same side of the Wilson trunk, W. C., B., No. 1479, that is shown in Pl. XCIX, but here the specimen is more inclined from the camera, so that the apical cavity is not seen. The equatorial zone is very distinct.

Pl. LXXXIX, Fig. 1, 3 gives an excellent view of the base and a portion of the external surface of the Dearstine trunk, M. G. S.-W. C., B., No. 9049. This is part of the base of a very large trunk, probably larger than W. C., B., No. 1479, but as that specimen was decayed at the base, this one supplies that deficiency. It has the same light-colored sandy character, and the specific characters all agree. This specimen is very unequally and obliquely broken across near the base, so that while one side actually reaches the base the other rises 20 cm. above it, but the rapid rounding off on that side indicates that the trunk was either much inclined or else greatly compressed vertically. There is little lateral compression and the diameter either way is about 36 cm. It weighs 17.24 kg. (Locality: Pl. LXXX, No. 103.)

Pl. XCIX shows the perfect side and the apex, with its depression, of the original type or Wilson trunk, W. C., B., No. 1479.

This is perhaps the most interesting of all the Maryland cycads, not only because its precise stratigraphical position is so well known, but also from its large size, its completeness, and the number of features it presents that are not possessed by any other specimen. It is unbranched and somewhat elliptical in cross section. The longer diameter is 47 cm. and the shorter 25 cm., measured at about the middle part. It does not vary greatly until near the summit, where it is quite rapidly contracted. Its maximum girth is 122 cm.; that near the top is 110 cm. It is obliquely truncated at the summit, but no great portion is wanting. The longer side shows a height of 47 cm. and the shorter of 35 cm. The fracture across the top is sunk in the middle and the average measurement does not exceed 39 cm. One side is complete except the loss of a small piece at the summit. The other side has lost a large irregular portion at the base, making an opening into the hollow interior 27 cm. high and varying in width from 10 cm. to 23 cm. A small piece was purposely broken out of this opening

and bears the number 1479a. This piece weighs 0.45 kg. and measures 5 by 8 by 13 cm. The specimen is somewhat hollow at both ends, but the depression at the summit is little more than a "crow's nest" and does not exceed 10 cm. deep. It is elliptical, 6 cm. by 17 cm. in diameter. The base presents a great cavity in the loss of nearly the entire medulla and part of the woody zone. It is 17 cm. deep, elliptical, and 13 cm. by 20 cm. in diameter at the lower end, tapering to half those dimensions above. There are several lesser cavities leading out of this into the wood and armor, like so many chambers, and there is one small cavity adjacent to the broken side which penetrates to the wood. These various losses afford excellent facilities for examining the interior of the trunk.

The color is light ash verging on white, the rock is soft and brittle, and would have been utterly destroyed if it had been exposed to conditions of erosion. It is also light in weight, the whole weighing only 45.8 kg.

One of the most remarkable features, possessed by this specimen alone, is a sort of girdle that passes entirely around the trunk near the middle. This is produced by the change in the angle that the leaves made to the axis all around on this line, those below it being somewhat deflexed, while those above it were decidedly ascending. The result is a V-shaped groove between the lower and upper leaf scars. This condition strikingly recalls the foliage of the tree yuccas of Mexico, in which a similar encircling line divides the erect and still green and growing upper leaves from the older, more or less dry, reflexed lower ones at the summit of the leafless trunks. In this specimen the encircling line passes just at the summit of the large opening on one side, and the upward tendency of the leaves on that side is much less marked than on the other, where, indeed, there are some indications that it may have been partially due to pressure, but it is difficult to believe that any conditions of compression could have caused the regular change that exists in the angle of the leaves to the axis. (Locality: Pl. LXXX, No. 43.)

Cycadeoidea Uhleri Ward.

Pl. LXXXVII, Fig. IV, 10; Pl. C.

1897. *Cycadeoidea Uhleri* Ward: Proc. Biol. Soc. Washington, Vol. XI, p. 14.

Trunks small, 28 cm. high, 20 cm. in diameter, 50 cm. to 60 cm. in girth at the thickest part, circular, or only slightly elliptical in cross section, conical or somewhat cylindrical-conical in shape, contracted at the base, silicified but porous and light, reddish or gray in color; leaf scars definitely arranged in quincunx order and spiral rows around the trunk, one of these sets of rows ascending at an angle of 45° to the axis, the other at a much greater angle; subtriangular, the upper side arched and sometimes slightly grooved, lateral angles acute, inferior angle obtuse or rounded; scars uniform in size, 18 mm. wide and 9 mm. high; ramentum walls 4 mm. to 5 mm. thick, commissure distinct, the whole punctured with minute rhombic, triangular, or elliptical bract scars deeply penetrating the structures; leaf bases usually wanting, but sometimes nearly filling the cavities; vascular bundles few, arranged in a row near the upper side of the petiole and others scattered over other parts; petioles all reflexed or pointing downward at a strong angle; reproductive organs numerous, situated directly over the leaf scars—i. e., axillary—elliptical in outline, 15 mm. wide, 10 mm. high, the center occupied by the remains of the essential organs or by a circular cavity where these have disappeared; bract scars small and numerous, somewhat curved and arranged concentrically around the spadix, also passing out into the ramentum walls; armor 3 cm. to 5 cm. thick; woody zone 15 mm. to 35 mm. thick, divided into two or three rings; medulla about 5 cm. in diameter, cylindrical or elliptical according to the shape of the trunk, heterogeneous in composition, being traversed by dikelike plates of a hard substance dividing it into chambers, often wanting, leaving a hollow center to the trunk.

No additional specimens of this species have come to light since it was described in 1897 from the two types then known. One of these is as perfect a specimen as any in the collections, and the species is one of the most distinct and well characterized of all of the fossil cycads.

Pl. LXXXVII, Fig. IV, 10, shows the external surface of the Crook fragment, No. 2, W. C., B., No. 1429. The trunk from which it was

broken must have been much longer. It was small and somewhat elliptical in cross section. The fracture at the upper end is nearly even, that at the lower end is irregular, the lowest point coinciding with the end of the ellipse, thence sloping upward in both directions, so that the shortest side is 6 cm. less than the longest. The specimen includes nearly all of the medulla. The color is a pinkish red throughout. The specific gravity is much less than that of most trunks, chiefly on account of the number of empty cavities, large and small. It weighs 3.42 kg. The total height is about 18 cm. The longer diameter is about 16 cm., but this falls a little on one side of the center. It was probably nearly 17 cm. The radial thickness is 11 cm., which includes about the whole of the medulla. (Locality: Pl. LXXX, near No. 53.)

Pl. C represents the perfect trunk No. 2 of the museum of the Maryland Academy of Sciences, otherwise known as the Lee trunk, being from a platinum print made by Mr. Smillie. It is a view of the side that shows the largest amount of surface and affords a clear idea of the specimen. It is a small, simple trunk, strictly conical in shape and nearly perfect both in the absence of fracture and in the state of preservation. It has suffered no compression or erosion and is nearly circular in cross section at all points. The maximum height is 28 cm., but the base is oblique (not due to fracture) and the shortest side measures only 23 cm. The diameter at the base varies from 17 cm. to 20 cm., and diminishes regularly to the apex, where it is 9 cm. at the point where it begins to narrow abruptly. The maximum girth is 58 cm. It is oblique at the summit and has suffered slightly from decay on one side. There is no terminal bud or true crow's nest, but an irregular cavity 2 cm. deep at one side of the center is partly occupied by the remnant of scale-like matter that may have belonged to the bud. The trunk is also rapidly contracted at the immediate base and seems to have grown on a steep slope, so that one side was naturally much lower than the other. The trunk is of a grayish-brown color throughout, silicified, but having a low specific gravity in consequence of its porosity. The weight is 7.66 kg. (Locality: Pl. LXXX, near No. 54.)

Cycadeoidea Bibbinsi Ward.

Pl. LXXXIII, Fig. 3; Pl. LXXXIV, Fig. 3; Pl. LXXXV; Pl. LXXXVII, Figs. I, 2, 4, 6, 7; II, 1, 2, 4, 8, 9, 10, 11; III, 5, 7; IV, 2, 3, 6, 8, 11; V, 12, 15; Pl. LXXXIX, Figs. I, 5; II, 2, 5, 6; Pl. CI-CIV.

1897. *Cycadeoidea Bibbinsi* Ward: Proc. Biol. Soc. Washington, Vol. XI, p. 15.

Trunks large, 40 cm. to 60 cm. high, laterally compressed, girth of largest specimen 1 meter, of next in size 88 cm., shorter axis of cross section one-half to two-thirds of longer axis, contracted toward the summit, terminating in a conical bud 30 cm. high, or, where this is wanting, in a concave depression, thoroughly silicified throughout, heavy and solid, of a dark color; all the organs of the armor nearly at right angles to the axis of the trunk; leaf scars arranged spirally around the trunk in imperfect quincuncial order, subrhombic, the lower angle much sharper than the upper, the latter sometimes reduced to a curve, 14 mm. high, 26 mm. wide; ramentum walls moderately thick, usually solid; vascular bundles of the petioles arranged in a row entirely around them and near the margin of a cross section, also sometimes a few near the center; spadices abundant, irregularly scattered over all parts of the surface, usually showing the marks left by the essential floral organs or a central cavity occupying their place, surrounded by curved or crescent-shaped pits concentrically arranged in several rows and set concave to the axis of the spadix, representing the involucral bracts; armor varying from 25 mm. to 75 mm. in thickness, this variation often great in different parts of the same specimen; cambium layer indistinct; liber zone not generally distinguishable from the wood; the latter in two or three zones, medullary rays faint; medulla well marked, homogeneous, usually spongy in appearance.

This species represents a type quite distinct from all the others, and the cycadean trunks of the iron-ore deposits of Maryland might be divided into two classes, one of which should embrace all the forms included in the six species above described, and the other those that have been referred to this species. The fact that the rock in the latter is always firm, hard, and heavy and usually dark colored is not merely an accident of preservation, but results in some obscure way from the nature of the vegetable tissues. The trunks are generally larger and the leaf scars much larger, though they have nearly the same form and

arrangement. The reproductive organs are more abundant and usually very regular and definite in their character.

This species now includes 27 specimens, the same number as *C. Fontaineana* and only one less than *C. marylandica*, these three species being by far the most abundant of all the Maryland Potomac cycads. The number of specimens belonging to this species has been increased by 9 since 1897, when it was first described.

The following is the list of the specimens, with their numbers, names, and weights:

	Weight in kilograms.
Johns Hopkins University cycad, No. 4	3.18
Johns Hopkins University cycad, No. 6	.15
Dawson cycad	3.50
W. C., B., No. 1426, the Harman trunk	3.63
W. C., B., No. 1427, the Polly Jones trunk ("growing stone")	58.62
W. C., B., No. 1462, the Butler trunk	20.18
W. C., B., No. 1463, the Carr trunk	9.52
W. C., B., No. 1464, the Welsh trunk	8.55
W. C., B., No. 1465, the Tubbs trunk	28.58
W. C., B., No. 1466, the All Saints trunk	17.24
W. C., B., No. 1468, the Weston trunk	28.81
W. C., B., No. 1478, the Travers fragment ("petrified fish")	6.58
W. C., B., No. 1480, the Ring fragment	8.35
W. C., B., No. 1482, the Smith trunk	10.55
W. C., B., No. 1483, the Smith fragment	8.28
W. C., B., No. 1484, the Linthicum fragment	11.23
W. C., B., No. 1487, the Robinson trunk	4.99
W. C., B., No. 3047, the Simmons fragment	2.50
W. C., B., No. 3054, the Snowden fragment	4.99
W. C., B., No. 3348, the R. P. Disney fragment, No. 1	3.63
W. C., B., No. 6351, the R. P. Disney fragment, No. 4	.37
W. C., B., No. 6353, the Dorsey trunk	10.66
W. C., B., No. 6354, the Gray trunk	14.29
W. C., B., No. 6356, the Travers trunk	5.26
W. C., B., No. 6357, the David Ring trunk	6.29
M. G. S.-W. C., B., No. 9048, the Allen fragment, No. 2	3.86
M. G. S.-W. C., B., No. 9059, the Marlowe fragment, No. 2	2.72

The only one of these specimens that has entirely escaped illustration is the Johns Hopkins University cycad No. 6, a small fragment recently found in the collections of the Johns Hopkins University with

a nearly illegible label indicating that it had been taken for a coral. It is somewhat triangular in shape, but shows four faces. Two of these are fresh breaks. A third is an old radial fracture and shows one fruit very clearly. The fourth side is external and, though deeply worn, shows scars characteristic of *C. Bibbinsi* of the type of W. C., B., No. 1480. One of the fresh fractures shows the lower end of a reproductive organ with radiate structure. The measurements of the fragment are: Tangential length, 9 cm.; width (probably nearly vertical) 6 cm.; radial thickness, 5 cm. The remainder will be described under the principal figures.

Pl. LXXXIII, Fig. 3, and Pl. LXXXIV, Fig. 3, are two views of the external surface of the Johns Hopkins University cycad No. 4, the first in the group photographed by Mr. Tyson of which he sent a print to Mr. Meek, the history of whose discovery is given in the historical part of this paper (p. 414), and the second in the group photographed by the United States Geological Survey on May 11, 1895. When I described this specimen on January 9, 1895, there were in the geological museum of Johns Hopkins University two large trunks (Nos. 1 and 2) and two fragments. As Professor Fontaine had treated two trunks and two fragments before they left the museum of the Maryland Academy of Sciences, and as these had since been donated to Johns Hopkins University, I naturally supposed that the ones I found there were the same. As Professor Fontaine had figured the trunks, there was no difficulty in identifying them. I also correctly identified one of the fragments I found with his description of the one he called "Fragment No. 2" on p. 192 of his monograph (see p. 457). As this was much the larger of the two I found, I called it and still call it "Johns Hopkins cycads, No. 3."[a] The other one, which is the one now under consideration, I called "No. 4," and supposed that it was the one that Professor Fontaine had called "Fragment No. 1." I could not make it agree with his description and passed it over without comment. When the third fragment came to light, a few months later, I also described that and had the three photographed in this group (Pl. LXXXIV), but I did not then compare them with Professor Fontaine's descriptions, and still supposed in 1897, when my descriptive paper was written, that this third

[a] See Proc. Biol. Soc. Washington, Vol. XI, p. 11.

fragment was unknown to Professor Fontaine. Such a comparison, however, shows beyond a doubt that the newly found specimen was his "Fragment No. 1," and that he did not mention and probably did not see this small fragment (No. 4).

It is a nearly square but somewhat rhombic slab from the side of a trunk of unknown size. To assume an erect position it must stand on one of the more acute angles, so that the longer diagonal would be parallel with the axis or nearly so. The trunk had evidently suffered from lateral compression, as shown by the great difference in the angle made by the leaf scars on the two fractured edges. It includes the armor and a portion of the woody zone. The substance is hard and heavy and the color is dark brown outside and light yellowish on the inner face. The sides of the rhomb measure 19 cm. and 20 cm., while the long and short diagonals are, respectively, 23 cm. and 20 cm. The thickness is 8 cm. In the view taken by Tyson (Pl. LXXXIII, Fig. 3) the specimen stood on one of its straight edges, which was not horizontal or perpendicular to the axis. In the one taken under my supervision (Pl. LXXXIV, Fig. 3) it was placed on one of its corners, so as to be in its normal position, the sharp angle of the alveoli representing the keel of the petioles being downward.

Pl. LXXXV is a view from a platinum print by Mr. Smillie of the outer surface of the Dawson cycad (see p. 409), which proved to belong to this species. This is a slab from the side of a moderate-sized trunk, not reaching either base or summit. The fracture is along a very even plane, exactly vertical, and passing out on the flattened side at one edge and the thin side at the other of the considerably laterally compressed trunk. In the first case it does not reach the surface, but there is an irregular radial fracture that meets at right angles. The top is also broken across at nearly right angles to the axis. All the fractures except a small part of the upper one are fresh, as if recently made intentionally. The surface is considerably worn and rather evenly so. The specimen is well silicified and minute quartz crystals sparkle on the broken surfaces. The outer parts and old fractures are of a light-drab to fawn color, but the freshly broken surfaces are pink, with white or rust-colored streaks and spots. The specific gravity is about medium. The maximum height is nearly 22 cm., but the base is oblique, reducing

the shorter side to 17 cm. The greatest width measured across the broken side is nearly 18 cm., but the radial fracture makes a triangular projection near the lower end and the width above this is only 14 cm. The greatest thickness of the slab is 6 cm.

Pl. LXXXVII, Fig. 1, 2 gives a view of one of the narrow sides of the Tubbs trunk, W. C., B., No. 1465.

Pl. LXXXVII, Fig. 1, 4 is an excellent view of the Polly Jones trunk, W. C., B., No. 1427, standing on its base. As the principal type of the species, it here compares well with those of *C. Goucheriana* and *C. Tysoniana*, between which it stands.

Pl. LXXXVII, Fig. 1, 6 shows the Weston trunk, W. C., B., No. 1468, but the terminal bud does not come out into relief as well as in the other figures.

With the exception of the worn condition of the exterior, this is one of the most perfect specimens in the collection. It is a whole trunk, from base to summit, including the terminal bud. It has evidently long stood on its base, perhaps under the dripping eaves of a house, and all definite markings have disappeared from the apex. The terminal bud is surrounded by a slight moat-like depression. A small piece has been broken from its extreme apex. For want of fractures anywhere, only surface characters can be seen. The trunk is much compressed laterally and has large concave depressions on its sides, so as to be thinnest in its central portions. Before compression it doubtless was nearly conical, but narrowed a little toward the base, especially on one side. It is of a light-brown color, lighter in some parts than in others, of a rough sandy consistency, but well silicified, and of medium specific gravity. It stands 37 cm. high. The long diameter is 34 cm. and the short one about 14 cm., but quite variable at different points. The average girth is 88 cm.

The best view of this trunk that has been published is that on Pl. lx, fig. 9, of the Nineteenth Annual Report of the United States Geological Survey, Pt. II, published in 1899, which shows the best preserved side and the terminal bud in fine relief.

Pl. LXXXVII, Fig. 1, 7 presents one of the thinner edges or sides of the Dennis Butler trunk, W. C., B., No. 1462, better shown elsewhere.

Pl. LXXXVII, Fig. 11, 1 is the only view offered of the Robinson trunk, W. C., B., No. 1487, standing on its edge in such a manner that to

see it in its natural position it is necessary to place the right side of the plate downward. This is a short piece of the base of a trunk of unknown height, much flattened longitudinally and laterally, so as to form a narrow, elongated object. The axis is largely decayed, so as to leave a cavity at each end. It is more even across the base than across the summit. The material is fine grained, as if argillaceous, of a light-slate color except superficial rust-colored patches, and not hard or heavy. The maximum height is 11 cm. and the minimum about 8 cm. It is 34 cm. in longer diameter and only 13 cm. in shorter diameter. The girth is 76 cm. (Locality: Pl. LXXX, near No. 74.)

Pl. LXXXVII, Fig. II, 2 is a fairly good view of the Linthicum fragment, W. C., B., No. 1484. It is a segment of a large trunk, broken transversely at both ends and radially on both sides, showing the outer surface about one-third of the way round, extending inward to the inner wall of the woody zone, which presents a concave surface corresponding to the convex outer one. The fracture at the lower end is very irregular, a sharp central portion projecting 9 cm. below the adjacent parts. The upper fracture is more even, but is also raised in the middle. The radial fractures are very regular and follow the leaf scars, thus rapidly converging. The specimen is thoroughly silicified, and a thin film on the outside of most of the broken surfaces has turned yellowish white and is covered with fine crystals (druse). The external surface is dark, the rest light and yellowish. The specific gravity is high. The maximum height is 29 cm. and the minimum 18 cm. The circumferential width (measured on the arc) is 35 cm. The corresponding measurement across the concave interior (measured on the arc) is 14 cm. The last two dimensions, taken on the chord instead of the arc, are, respectively, 24 cm. and 12 cm. The radial thickness is about 12 cm. and nearly uniform. The leaf scars are very large, averaging 16 mm. high and 28 mm. wide. (Locality: Pl. LXXX, No. 62c.)

Pl. LXXXVII, Fig. II, 4 is a view of the Dorsey trunk, W. C., B., No. 6353. It is a very large fragment, probably representing a third of the trunk, very irregularly broken. One side seems to reach near the summit, where there is a depression which may represent a crow's nest. The lower part is wholly wanting from a very irregular diagonal fracture. The interior seems to have been hollow. The surface is

much worn and whitened and shows many large, solid fruits, similar to W. C., B., No. 1484. It is 29 cm. high and 28 cm. in maximum diameter. The rock is lighter and more porous than most of the specimens of this species. (Locality: Pl. LXXX, No. 45.)

Pl. LXXXVII, Fig. II, 9, shows one of the narrower sides of the Gray trunk, W. C., B., No. 6354, fully illustrated on Pl. CIV.

Pl. LXXXVII, Fig. II, 10, is a good group view of the Smith trunk, W. C., B., No. 1482, and shows the terminal bud clearly. This is a much worn and laterally compressed trunk, but apparently almost complete. It is exceedingly oblique at the base, and presents the appearance of having leaned 40° to 45° from the perpendicular. There is a well-defined conical bud at the apex, which, however, looks as if it grew from one side, but standing the trunk on its oblique base renders this bud vertical, as it doubtless was when growing. It is set in a slight depression and surrounded by much worn scars of leaves and bracts. The material of this specimen is a light-colored sandstone, quite soft, but except where worn off it is covered with a black pigment, probably due to vegetable growth. The height in the direction of the axis and terminal bud is 17 cm., but the broad face on the side of which the bud stands is 25 cm. from base to highest point. This face is 28 cm. wide. The maximum thickness is 12 cm., but at some points this is reduced to 9 cm. It has a girth of 67 cm. (Locality: Pl. LXXX, near No. 49.)

Pl. LXXXVII, Fig. II, 11, shows the outer surface of the Smith fragment, W. C., B., No. 1483.

This is a very irregular fragment from the side of a trunk that was probably of large size. The position it occupied on the trunk can not be ascertained, but it may have been near the base. It includes a considerable portion of the axis, one of the main fractures being a vertical radial one, and the other at right angles to it also radial, but very oblique to the axis, running out to the surface on one side. The third fracture is transverse, and the whole fragment has a sort of triquetrous shape, the outer surface forming the broader side and having the rounded form of the trunk. Over most of the surface the upper parts of the leaf scars have been systematically, and as it seems artificially, broken off to a depth of 2 cm. or 3 cm., usually to near the bottom of the depressions. The portions left, however, afford a fairly correct idea of the whole. The rock is

hard and more or less crystalline, generally of a dark-reddish color, but lighter where freshly broken, and rather heavy. In its longest dimension, which is nearly along the oblique radial fracture, it is 30 cm. The width at right angles to this is 16 cm. The length of the axis running obliquely across this face is 15 cm. The maximum measurements over the curved outer surface are 21 cm. by 36 cm. A polished section is shown on Pl. CIII. (Locality: Pl. LXXX, No. 59a.)

Pl. LXXXVII, Fig. III, 5, is a view of the best preserved broad side of the Carr trunk, W. C., B., No. 1463. It shows the terminal bud, but not so well as it is shown on pl. lx, fig. 8, of the Nineteenth Annual Report of the United States Geological Survey, Pt. II.

This specimen consists of the upper portion, probably more than half, of a very much laterally compressed cycad. The compression is greatest in the central portions, but the thinnest place is not opposite the medulla, but on one side of it. The specimen is much worn on all sides, but enough is left to show that it was originally covered with the usual appendicular organs. The fracture is oblique, so as to make both the sides and ends unequal. The most important feature of the specimen is the smooth-worn but still well-preserved terminal bud, which rises nearly 3 cm. above the otherwise flat general surface of the trunk in the form of a small cone about 5 cm. in diameter at the base. It is slightly flattened at the apex, which may have been due to injury. Bract scars occur around its base, but not on the rest of the summit of the trunk. This indicates greater wear at a short distance from the bud, and shows that the latter was originally set in a depression or crow's-nest.

The trunk is of a light color and firm consistence and of high specific gravity. The height, including the terminal bud, is 21 cm. measured on the median line, but one of the lower sides extends 4 cm. lower, making a total of preserved substance of 25 cm. This is also about the length of the longer edge, while the shorter edge is only half as great. The total length of the oblique fracture is nearly 32 cm., but the major axis at the lowest point at which it can be measured is 25 cm. Judging from the rate of contraction, that of the lowest point represented would have been 33 cm., and the maximum might have been somewhat greater than this. The minor axis varies from 7 cm. at the thinnest place to 13 cm. at the summit, where it is thickest. The girth at the lowest place attainable is 74 cm.

Its maximum must have been 80 cm. or 85 cm. (Locality: Pl. LXXX, No. 67.)

Pl. LXXXVII, Fig. III, 7, is a good side view of the Welsh trunk, W. C., B., No. 1464.

This is a much laterally compressed fragment lacking base and summit and also a considerable part of one side, which is now one of the edges of what is little more than a slab. The fractures at the ends are oblique, especially the upper one, so that the height, which is 26 cm. on the longest side, is only 16 cm. on the shortest. The basal fracture is also very oblique in the short direction, so that one of the flat sides is 7 cm. to 8 cm. longer than the other. The missing part from the side (edge) included the whole of the armor and extended to the medulla. One side of the specimen is very much worn, the other much less so; the edge that remains is also in a fair state of preservation. The rock is rather light colored, but heavy and solid. (Locality: Pl. LXXX, No. 67.)

Pl. LXXXVII, Fig. IV, 2, represents the Harman trunk, W. C., B., No. 1426.

This is a fragment apparently from near or at the base of a moderate-sized trunk which was very much laterally compressed. It includes part of both of the flat sides, but more of one than of the other, and the whole of one of the narrow sides or edges. The vertical fracture is oblique to the major axis of a cross section, and falls considerably on one side of the center, preserving the smaller piece. The lateral fracture is oblique to the axis, so as to make the broader side longer than the narrower one. Viewed from above, all the parts are seen to be about equally affected by the flattening. The specimen is thoroughly silicified, hard, fine grained, and rather heavy, of a dark-brown color. It is 18 cm. high measured on the longer side. Its maximum width is 19 cm., which is that of the broader side. Its thickness is 10 cm., which is probably somewhat less than the minor axis of a cross section. The major axis can of course only be conjectured, but it was probably 25 cm. or 30 cm., the portion of it that remains being 14 cm. The whole amount of surface preserved, or partial girth, is 33 cm. (Locality: Pl. LXXX, No. 52a.)

Pl. LXXXVII, Fig. IV, 3 is a view of the R. P. Disney fragment, No. 1, W. C., B., No. 3348. This is shown to somewhat better advantage in the Nineteenth Annual Report of the United States Geological Survey, Pt. II, pl. lx, fig. 7.

It is a small fragment from the side of a large trunk, convex without and concave within, like a segment of the wall of a cylinder. There are some indications that it may have belonged near the base, but this is not certain. The fracture on the lower side is irregular, the inner part projecting below the outer; it is also oblique on both sides, but unequally so, one side rising almost to the line of the upper fracture. The latter is nearly horizontal, but lower in the middle. The specimen is well preserved, thoroughly silicified, firm, and moderately heavy. It is of a light-brown color. The maximum length preserved is 14 cm., but this is on the inside. Of the external surface it is nowhere more than 10 cm. Its greatest dimension is tangential and slightly exceeds 24 cm., but an arc on the external surface between the same points measures 27 cm., and on the internal 20 cm. The radial thickness varies from 8 cm. to 11 cm. (Locality: Pl. LXXX, No. 50.)

Pl. LXXXVII, Fig. IV, 6 shows very well the outer surface of the Ring fragment, W. C., B., No. 1480. It is a much worn fragment from the side of a large trunk, perhaps near the base, showing the armor and woody zone only. It is moderately silicified, and a fresh fracture shows a somewhat sandy appearance. The color of the outside varies from a light brown to reddish, and at one end black, but this latter is only a stain. The exposed outer surface is 23 cm. in vertical and 27 cm. in circumferential measurement, but there is very little curvature to the latter. The fractures wedge in toward the interior so that the corresponding dimensions of the inner surface are 17 cm. vertical and 14 cm. lateral. The thickness is about 10 cm., and the concavity somewhat exceeds the convexity. The thickness was doubtless considerably greater before the surface was eroded. (Locality: Pl. LXXX, No. 62.)

Pl. LXXXVII, Fig. IV, 8 is a view, somewhat obscured by the specimen standing before it, of the outer surface of the Snowdon fragment, W. C., B., No. 3054, lying on its side. It is a compact fragment, of a somewhat circular form, broken out of one side of a large trunk, the fractures on all sides following the direction of the organs of the armor. This is always at a greater or less angle to the nearly flat outer and inner surfaces, but on one side the angle is slight, while on the other it is about 45°, which shows that it must have been near the narrower side or edge of an elliptical trunk, while the opposite side of the fragment represents its

broad side. The specimen thus has the shape of a saucepan, the inner face being much reduced by the convergence of the edges on all sides. It has, superficially at least, a lurid red color from the paint clay in which it was embedded and which, when it was found, filled all the cavities, but was not cemented and was readily washed out, but the stain is permanent. The specimen is hard, firm, and heavy, and slightly crystallized in places, while the inner face is somewhat chalcedonized, as are also some of the walls of exposed vessels. In an erect position it has a height of 23 cm. and precisely the same width. The same measurements on the inner face give 19 cm. and 10 cm., respectively. The maximum thickness is 11 cm. (Locality: Pl. LXXX, No. 104.)

Pl. LXXXVII, Fig. IV, 11 shows very clearly the well-marked alveoli on the surface of the Travers fragment, W. C., B., No. 1478.

This is a well-preserved fragment from the side of a large trunk, apparently beginning at the base and including a considerable area of the exterior and extending inward to include the whole of the medulla. The fractures are all clean and clearly show the internal structure. The cross section above is perfectly square. The rock is very hard and heavy, some portions somewhat cherty and crystallized. It is dark or brownish red near the outer surface, lighter colored within. The height on the longest side is 16 cm., elsewhere reduced by irregularities to 11 cm. or 12 cm. The part of the surface preserved measures 25 cm. in arc. The radial thickness is 14 cm. at the base and 11 cm. at the top. A line drawn through the center of the medulla measures 25 cm., but this only reaches the surface at one end. The medulla was considerably on one side of the center. (Locality: Pl. LXXX, No. 77.)

Pl. LXXXVII, Fig. V, 12 presents one of the broken surfaces of the R. P. Disney fragment, No. 4, W. C., B., No. 6351. This is a very small fragment, having a narrow elongated form and showing much distorted and much worn scars on one side and the outwardly curving strands, tubes, and scars passing into the leaf bases on the inner side. It is 14 cm. long, 6 cm. wide in tangential direction, and 3 cm. thick in radial direction. (Locality: Pl. LXXX, near No. 50.)

Pl. LXXXVII, Fig. V, 15 is a chiefly interior view of the Simms fragment, W. C., B., No. 3047. It is a fragment from one side and edge of a much flattened trunk probably of small size and not much longer than the

specimen. The compression was greatest in the middle, so that the inner edge is thinner than the outer. The lower end may represent the true base. It consists almost entirely of armor, the axis having mainly disappeared before compression. It extends more than halfway around. It is oblique at the base and also at the summit in such a manner as to make the two cross sections parallel. There is a kind of groove or hollow trough on the inner edge, but one side of the armor projects farther in that direction than the other. It is of a light-brown color, darker where freshly broken, rather hard and firm, but not heavy. Its maximum length from point to point is 27 cm., but measured along either edge it is only 19 cm. The wider side is 13 cm. and the narrower 10 cm. The greatest thickness is less than 8 cm., while at the inner edge it is not over 5 cm. The surface is covered with the organs of the armor, which on one side are completely appressed to the rock and merely point outward or toward the edge of the specimen. On the other, which is the broader, side they are fairly well preserved, seem to stand at right angles to the trunk, and were probably arranged in spiral rows, but these can not now be traced. (Locality: Pl. LXXX, No. 102.)

Pl. LXXXIX, Fig. 1, 5 shows one side of the Travers trunk, W. C., B., No. 6356.

This is a small, nearly complete, probably immature trunk of compressed cylindrical shape, much worn over the whole surface, so as to show none of the leaf scars to advantage, the erosion penetrating the inner wood and even to the medulla on one side. The base is hollowed out to a depth of 6 cm. The summit is entire, but from one side of it a piece 8 cm. long is broken out, exposing the upper end of the axis converging to the terminal bud, which is not present. The trunk stands 30 cm. high, is 17 cm. in greater and 9 cm. in lesser diameter, slightly contracted at base and summit. The maximum girth around the middle is 42 cm. (Locality: Pl. LXXX, No. 69.)

Pl. LXXXIX, Fig. 11, 2 represents the Marlowe fragment, No. 2, M. G. S.-W. C., B., No. 9059, which is a piece out of one side of a moderate-sized trunk, and has a maximum length of 13 cm. It includes only the armor and wood and is concave on the inner side, showing obscure markings of the medullary rays. The radial thickness is 9 cm. and the tangential length 22 cm. (Locality: Pl. LXXX, No. 100.)

Pl. LXXXIX, Fig. II, 5 shows well the perfect side of the David Ring trunk, W. C., B., No. 6357. This is nearly half of a small trunk with small scars, type of W. C., B., No. 1478, but still smaller. Besides the longitudinal fracture which has carried away most of the axis, leaving a hollow trough showing markings of the inner wall of the woody zone, there is a transverse fracture at each end, probably near the base and summit. It is 25 cm. high and 21 cm. in diameter, which was nearly that of the trunk. (Locality: Pl. LXXX, No. 55.)

Pl. LXXXIX, Fig. II, 6 shows, lying on its side, the worn outer surface of the Allen fragment, No. 2, M. G. S.-W. C., B., No. 9048.

This is a trough-shaped fragment showing probably almost the whole length of one side of a small cylindrical trunk, the hollow interior barely reaching the medulla, and showing the markings of the inner wall of the woody zone. The external surface is badly worn, and the whole specimen is stained reddish brown by contact with paint stone. Neither base nor summit is preserved. The height is 34 cm. and the tangential diameter is 15 cm. The true diameter could scarcely have exceeded 16 cm. (Locality: Pl. LXXX, near No. 101.)

Pl. CI represents the Polly Jones trunk, W. C., B., No. 1427, in its proper position, or standing on its base. It is from a photograph taken by the Woman's College. This specimen has been taken as the principal type of the species. It probably constitutes the greater part of the original trunk, but portions of both base and summit are wanting. It stands 50 cm. high on the longest side. The base being somewhat oblique the vertical length of the shorter side is only 40 cm. The size is nearly uniform for all points and the girth is approximately 1 meter. It is very much flattened longitudinally, and more so at the top than at the bottom, so that, looked at from the broad side, it seems to expand slightly upward. The long diameter is at the base about 40 cm. and at the summit 43 cm. The short axis is about 16 cm. at the base. At the summit the compression is greatest in the middle, forming a sort of groove on both sides, but deeper on one side than on the other. A cross section of the trunk would therefore be somewhat irregularly fiddle shaped, and the minor axis would measure 12 cm. in the middle and 14 cm. at either end.

The specimen is thoroughly silicified and very heavy. It is of a brownish-gray color, darker below. The external surface is very little

worn and the leaf scars and reproductive axes are distinctly shown. The former are arranged in irregular quincunx order, and spiral rows ascend from left to right at an angle of about 35° from the horizontal. One of these spirals, if it could be traced the entire distance, would nearly complete a circuit of the trunk in passing from base to summit. (Locality: Pl. LXXX, No. 59.)

Pl. CII, Fig. 1 is an excellent side view of the Dennis Butler trunk, W. C., B., No. 1462. It is a medium-sized trunk with a very eccentric axis, lacking the armor on the thin side, nearly complete at the base, truncated at the summit, with a large piece missing from one side, otherwise entire. Its maximum height is 36 cm., and the longer diameter of a cross section would be 30 cm. The shorter diameter is 16 cm., but it was probably 18 cm. The girth is 74 cm. The surface has been much worn, most on the otherwise defective side. The trunk is of a light-brown color, thoroughly silicified, portions of the internal parts being covered with fine quartz crystals or druse. (Locality: Pl. LXXX, No. 52a.)

Pl. CII, Fig. 2 shows the Tubbs trunk, W. C., B., No. 1465, at its best. This is a large, fine trunk, somewhat elliptical in cross section, nearly complete at the naturally hollow base, deeply concave at the summit, where an unknown portion is wanting. It is of a dark color, well silicified, and in an excellent state of preservation. The maximum height is 32 cm., but measured on the short side it is 28 cm., and at the lowest place 26 cm. The girth is 95 cm. The long diameter at the base is 34 cm., and the short one 25 cm. At the summit the diameters of the cross section are, respectively, 33 cm. and 21 cm. (Locality: Pl. LXXX, No. 46.)

Pl. CIII shows, natural size, the internal structure of the Smith fragment, W. C., B., No. 1483, as brought out on the polished surface of a longitudinal radial section. It extends through the thick armor, the cortical parenchyma, and the fibrous zone into the medulla, and the course of the vascular bundles can be clearly traced. This specimen is also described on page 868. (Locality: Pl. LXXX, No. 59a.)

Pl. CIV is a view of the side of the Gray trunk, W. C., B., No. 6354, from a photograph made by the Woman's College.

This is the upper part, probably more than half, of a fine trunk which looks as though it might be the complement of W. C., B., No. 1464,

but does not exactly match that trunk. It is 21 cm. high, 34 cm. in greater and 17 cm. in lesser diameter at the top, where it is thickest, the sides being deeply pressed in below, so that it is only 11 cm. thick at the transverse fracture. The maximum girth is 81 cm. The fracture is even and the summit is perfect, showing a depression with a low prominence in the center surrounded by polygonal scars concentrically arranged. (Locality: Pl. LXXX, No. 57.)

CYCADEOIDEA FISHERÆ Ward n. sp.

Pl. LXXXVII, Fig. III, 9; Pl. CV.

Trunks rather small (about 30 cm. high and 20 cm. in diameter), conical, unbranched; rock soft, light buff colored, of low specific gravity; leaf stalks strongly inclined, making an angle with the axis of the trunk of nearly 45°; rows of scars very distinct, spirally arranged around the trunk, those from left to right making an angle with the vertical axis of about 45°, those from right to left of about 30°, the latter much the more obvious and curving upward, so that the angle varies from 45° below to 25° above; leaf scars subrhombic, the two upper ones often forming a gentle arch, sometimes nearly a horizontal line, making the alveoli true triangles, the lower 2 cm., the upper 12 mm. wide, about 1 cm. high, diminishing toward the summit; leaf bases usually present, soft, sandy, and fine grained; rarely reaching the surface, generally sunk to a depth of 5 mm., sometimes of 2 cm.; vascular bundles often visible either as slight protuberances on the ends of those leaf bases that rise highest in the scars, or as small dots on those that lie deeper, or as a series of ridges running down into the scars where the central portion is deeper than the outer portion, the rows 0.5 mm. from the outer margin, with occasional faint traces of more central bundles; ramentum walls when normal about 5 mm. thick, of a rather firm consistency, presenting a continuous sharp ridge in the direction of the rows of scars from right to left, without visible commissure; reproductive organs abundant, one in the axil of each leaf, small and doubtless mostly abortive, occupying wide triangular spaces between the leaf scars, causing the walls to appear abnormally thick; spadices always present and flush with the walls, elliptical or circular in cross section, the larger ones 2 cm. wide and 1 cm. high, often much smaller; involucral scales abundant, occupying most of the space between

the walls, concentrically arranged in groups of thin, crescent-shaped scars, which are always somewhat depressed and contain the bases of the scales; essential organs visible at the center of the best preserved spadices, but often wanting and represented by a cavity; armor 3 cm. thick; woody cylinder consisting of two layers or rings, the outer, or cortical parenchyma 2 cm. thick, open and loose in structure, the large vascular strands passing upward and outward through it to enter the leaf bases, where they suddenly arch over and assume the downward course of the leaves, the inner or fibrous zone, 5 mm. thick, very distinct from the outer, the strands rising from its outer surface and not penetrating it, its fibers being longitudinal, its inner walls showing the longitudinal rows of the alternating ovate scales of the medullary rays; medulla represented in the only specimen known by a narrow band 5 mm. thick of rough, dark, crystalline rock substance with peculiar plates of a finer white rock crossing it in the form of dikes.

This species is thus far known only by the thin slab, W. C., B., No. 6345, called the Hegeman trunk from Stemmers Run, being almost the only cycad from any point east of the meridian of Baltimore. Although so incomplete a part of the entire trunk, still it contains the greater part of the specific characters, and constitutes one of the most distinct species of the genus known. It is also one of the most beautiful of cycads, and it gives me great pleasure to name the species in honor of the late Mrs. Mary Fisher Goucher, née Mary Fisher, who was largely instrumental in the establishment and development of the Woman's College, and thereby to help perpetuate one of the finest names in the history of the city of Baltimore.

Pl. LXXXVII, Fig. III, 9 shows well the relative size and general appearance of the specimen.

Pl. CV presents the outer surfaces. It is from a photograph made by the Woman's College of Baltimore, and clearly brings out most of the characters of the species. This specimen consists of a slab from the flat side of a trunk of conical shape. It is convex on the outer and concave on the inner surface, with indications that the trunk was hollow before entombment. It extends from the base to near the summit, and is 28 cm. high, 19 cm. wide below, and 14 cm. above. The specimen weighs 2.83 kg. (Locality: Pl. LXXX, No. 42.)

CYCADEOIDEA CLARKIANA Ward n. sp.

Pl. LXXXIX, Figs. 1, 2, 4; Pl. CVI.

Trunks rather large, tall and subcylindrical or barrel-shaped, laterally compressed, unbranched; rock rather hard, of a light-ash color and average specific gravity; organs of the armor horizontal or somewhat descending; rows of scars from left to right making an angle with the axis of 45°, those from right to left an angle of 80°; leaf scars subrhombic or irregular in shape and variable in size, 15 mm. to 18 mm. wide, 10 mm. to 15 mm. high; leaf bases present, sunk about 1 cm. below the surface, porous; vascular bundles not visible on the cross sections, but distinct on the eroded surfaces; ramentum walls very thin and sharp edged, thickening below to 3 mm. to 5 mm. hard, destitute of markings or division line between the plates; reproductive organs obscure and reduced to pitted areas on the eroded surface; armor 3 cm. thick, the leaf bases passing insensibly into the woody axis; wood 2 cm. thick, in four layers or rings; outer layer 1 cm. thick, chiefly composed of the elements of vascular tissues passing upward and outward through it and curving over at the outer margin to enter the deflexed leaf bases; fibrous zone of three rings, the outer and inner consisting of loose, open tissue, largely decayed in the only specimen that shows them, leaving a fissure, the middle ring hard and firm, forming a plate surrounding the medulla, 5 mm. thick, its inner surface regularly marked with the scars of the medullary rays, which are elliptical in shape and disposed in alternating rows; medulla very large and prominent, elliptical in cross section, thickest in the middle of the trunk to conform to its shape, which it chiefly determines, the shorter diameter varying from 9 cm. to 15 cm. and the longer from 14 cm. to 18 cm., coarse grained and homogeneous in structure, its surface where exposed handsomely marked by the ridges and flutings of the bases of the medullary rays rising out of it.

This species is known by two of the later acquired specimens, the Whitehead trunk, No. 1, M. G. S.-W. C., B., No. 9050, and the R. T. Donaldson trunk, No. 2, M. G. S.-W. C., B., No. 9052, both found in the Patuxent Valley south of Laurel, but probably not at the same spot, so as to warrant the conclusion that might be drawn from their appearance that the latter forms a part of the missing upper portion

of the former. It is a very distinct species and the only one of the Maryland Potomac species that has the tall subcylindrical form.

These specimens were collected under the joint operation of the Woman's College and the Maryland Geological Survey, and it therefore seems appropriate to name the species in honor of the energetic and efficient head of that survey, Prof. William Bullock Clark.

Pl. LXXXIX, Fig. 1, 2, shows the eroded side of the Whitehead trunk, No. 1, M. G. S.-W. C., B., No. 9050, by the side of other trunks. It is fully illustrated on Pl. CVI.

Pl. LXXXVII, Fig. 1, 4, represents the R. T. Donaldson trunk, No. 2, M. G. S.-W. C., B., No. 9052, which is not a trunk at all, but a piece of the upper end of the medulla of some large trunk, and from comparison it might well have belonged to the type specimen, No. 9050, found near the same place, but this is not proved. It may be the whole of the pith of a small conical trunk. It is subconical in shape, swelling out rapidly near the lower end and hollow within at that part. There is a curious partition across this cavity, dividing it into two unequal parts. It is 20 cm. high, 11 cm. by 17 cm. in diameter at the base, with a girth of 44 cm. Above the swelling the girth is reduced to 36 cm. and near the top to 25 cm. It weighs 2.55 kg. (Locality: Pl. LXXX, No. 106.)

Pl. CVI represents the best-preserved side of the Whitehead trunk, No. 1, M. G. S.-W. C., B., No. 9050. It is from a photograph made by the Woman's College. This specimen has furnished all the specific characters known. It represents a large, handsome, barrel-shaped trunk of which all above about the middle is wanting, and the part that remains has suffered much from erosion and decay. The figures show it so fully that special description is scarcely necessary. It has a maximum height of 34 cm. The longer and shorter diameters at the lower fracture are 25 cm. and 13 cm., respectively, and at the upper end 29 cm. and 18 cm. The girth at the corresponding points is 65 cm. and 78 cm. It weighs 17.24 kg. On the two flat sides the erosion reaches the cortical parenchyma and clearly displays the structure caused by the bundles of strands running out into the leaf bases. (Locality: Pl. LXXX, No. 105.)

RECENT COLLECTIONS OF FOSSIL PLANTS FROM THE OLDER POTOMAC OF VIRGINIA AND MARYLAND.

Professor Fontaine's report on all the Potomac material that had been sent to him was received on November 12, 1902. The type specimens designated by him to be drawn arrived in advance of the report and work upon them was begun in the division of illustrations in December. The report is not a systematic paper like most of those of Professor Fontaine, but simply gives the results of his examination of the numerous collections in his hands. These he treats separately, so that each collection forms a special report. It therefore amounts practically to a series of reports on material from different localities, which are susceptible to any arrangement that may be considered most advantageous. As, however, in a number of cases specimens had been collected more than once from the same locality, and sometimes by different collectors who did not always designate it by the same name, and as these also are treated separately, it has been thought best to combine them and to treat all the forms coming from the same locality and formation under one head, irrespective of the date of collection as well as of the particular person who obtained them. As all the specimens bear careful labels and marks showing these details, including the proprietorships of the fossils, this will lead to no confusion in the final disposition of the collections. All those representing new species or deserving special treatment or illustration are accompanied by full descriptions of their sources, and due credit is given to the collector and to the institution to which they belong.

As nearly all the specimens in these numerous collections belong to species that have been described and figured in earlier works, chiefly in Professor Fontaine's Potomac or Younger Mesozoic Flora,[a] he usually contents himself with their identification accompanied by references to the original source. Some of the material, however, add somewhat to the knowledge of the rarer species, and where this is the case the specimens best showing characters are figured in this paper. The most important result is the correlation on this the principal paleontological evidence of the new plant-bearing beds, especially of those in Maryland, from which no fossil plants had previously been reported, with the

[a] Monogr. U. S. Geol. Surv., Vol. XV, 1889.

known plant beds in Virginia. This evidence is put in more available form in the table of distribution which I append to the report.

Several years ago I was informed that the United States National Museum was to undertake the publication of a revised edition of my Guide to the Flora of Washington and Vicinity,[a] bringing it down to date and rearranging the matter to conform to modern ideas of classification and nomenclature. The different departments were to be elaborated by specialists in each. I offered to revise the introductory matter and to contribute a chapter on the fossil plants from all localities falling within the area covered by the original work. This, in brief terms, extended from Great Falls on the north to Mount Vernon on the south, and back from the river to the Piedmont Plateau on the west and to the divide between the Potomac and Patuxent drainages on the east. Of the localities treated in Professor Fontaine's report now to be considered it would therefore have included the following:

Mount Vernon.
Hell Hole.
Mouth of Hell Hole.
Chinkapin Hollow.
Sixteenth street, Washington.
New reservoir, Washington.
Terra Cotta, D. C.
Ivy City, D. C.
Langdon, D. C.
Queens Chapel road, D. C.
Rosiers Bluff (Fort Foote), Md.
Riverdale, Md.
Berwyn, Md.
Bewley estate, Md.
Muirkirk, Md.
Contee, Md.

Some of these localities were unknown at that time, but I had in my hands the collections from Mount Vernon, Chinkapin Hollow, Sixteenth street, the new reservoir, Terra Cotta, Rosiers Bluff, and Muirkirk, nearly as they are known at the present time.

I set about, as time would permit, the determination of these collections, and studied many of the specimens, giving names to several new species and preparing a list of all the fossil plants that would belong to the flora of Washington and vicinity. I intended to describe the new species and to write the chapter, but learned that the publication of the revised edition had been somewhat indefinitely postponed. I therefore suspended work on these collections, and when the time came for the general treatment of the Potomac flora for the present paper I

[a] Bull. U. S. Nat. Mus. No. 22, 1881.

sent them all to Professor Fontaine with my notes and labels, embodying the results of my studies. He has accepted my names for the new species, except in the cases where his wider experience showed that I was in error, and this accounts for a considerable number of the new species having been named by me. The descriptions, however, are in most cases those of Professor Fontaine.

Professor Fontaine's mode of treatment above referred to enables me to arrange the localities in a definite order, and I have thought best to make the arrangement chiefly geographical, beginning with the most southerly localities in Virginia and proceeding northward. This arrangement has the advantage of practically separating the States of Virginia and Maryland. As it is understood that the State Geological Survey of Maryland is to reproduce as much of this paper as is considered desirable in illustrating the geology and paleontology of that State, it may now, if it prefers, confine itself to that portion of the report relating to Maryland only. The localities falling within the limits of the District of Columbia are also placed together, although it is understood that the Maryland State Survey includes the District. In treating the localities in the State of Maryland I begin with Rosiers Bluff, on the Potomac River at Fort Foote, and pass from this in a general northeasterly course, following as nearly as practicable the direction of the strike. A number of the Maryland beds yield nothing but vague, indeterminable impressions of plants, but Professor Fontaine has examined the material, and I leave his remarks upon such localities for whatever they may be worth. Those localities which occur on the map (Pl. LXXX) are there numbered, and in all such cases the number is given.

As the paper is not in any sense a systematic one, but wholly geographical and stratigraphical, an alphabetical arrangement of the species enumerated from each of the numerous localities seems upon the whole the most practical and convenient method of treatment.

REPORT ON VARIOUS COLLECTIONS OF FOSSIL PLANTS FROM THE OLDER POTOMAC OF VIRGINIA AND MARYLAND.

By Wm. M. Fontaine.

INTRODUCTION.

A number of years ago I made a large collection of fossil plants from the Lower Potomac of Virginia and Maryland. The results of the study of these fossils were published in 1889 as Monograph XV of the United

States Geological Survey. Since that time a large amount of material has been obtained from these beds. Most of the plants furnishing the basis for the results given in that work were secured from localities in Virginia. In the collections made later a very large proportion of the fossils come from Maryland, being secured for the most part by Mr. Arthur Bibbins, of the Woman's College of Baltimore, and by the Maryland Geological Survey. A good many specimens have been secured by Professor Ward from a new horizon, not known at the time of the publication of Monograph XV. The strata yielding these plants have been named by Professor Ward the Mount Vernon series. Professor Ward and others have also made considerable collections from Fort Foote, on the Maryland side of the Potomac River, from the excavation for the new reservoir at Washington, and from various other localities in Maryland, the District of Columbia, and Virginia.

All of these collections have been turned over to me for study and description, in order that the publication of data relating to the fossil flora of the Lower Potomac of the Atlantic States may be brought up to date. The object of the present paper is to give the result of such study. By far the greater part of this material, obtained since the publication of Monograph XV, is composed of species described in that work. Some of the collections were made from new horizons or from those whose relations to the horizons yielding the plants there described are unknown. Many of them are from localities remote from one another, so that the territory occupied by the Lower Potomac flora of the Atlantic States is now much more fully represented by fossil plants than it was at the time of the publication of Monograph XV. It is surprising to find so few new species represented in this large additional supply of material.

In dealing with this more recently obtained matter, in order that it may serve to determine the geological horizons from which the plants were obtained, it seems best to take up the collections separately and compare the plants in them with those from the horizons and localities described in Monograph XV. The few new forms that have been found will be described and figured in their proper places. Where good specimens of previously described species are obtained they will be figured in some cases, for the sake of comparison.

The collections have very unequal value, owing to difference in their size and in the perfection of preservation of the impressions. In

some localities where the plants seem to have been abundant the rock matter was not adapted to preserve them. In other cases the material seems to have floated for a long time in water and hence it is much macerated and comminuted.

The abundance of plant impressions at a given locality can not always be determined from the size of the collections made there. In some cases the collection is the result of a single visit, in which only a short time was spent in collecting, with no facilities for securing the plants. In other cases repeated visits were made for the express purpose of collecting.

In the various collections some species are much more abundant than others. This is not always due to the greater actual abundance of these plants, for the accidents of preservation have had much to do with the proportion of the different forms. But notwithstanding this, the only way in which an idea of the importance of given plants in the flora can be obtained is by noting the proportion of the fossils they have left. For this reason, in giving an account of the different collections, the number of specimens of the various species will be indicated by actual count.

LOCALITIES IN VIRGINIA.

Professor Ward has made the following divisions of the Lower Potomac of that State, taken in ascending order: (1) James River; (2) Rappahannock; (3) Mount Vernon; (4) Aquia Creek. In the writer's opinion the James River and Rappahannock are essentially the same. Professor Ward's investigations show that the Aquia Creek beds are only a few feet above the Mount Vernon strata and that there is much in common in their flora. The Aquia Creek beds may be taken to represent both. The principal difference in the flora is found in passing from the Rappahannock into the Aquia Creek.

These two horizons differ in some important points. The Rappahannock horizon contains a large proportion of still surviving Jurassic types. The dicotyledons are very few in species and very rare in specimens. They are, with hardly an exception, archaic in type, having a vague, straggling nervation, with no marked differentiation in the development of the nerves subordinate to the midrib. On the other hand, in the Aquia Creek beds that occur at the Brooke locality we find compar-

atively few Jurassic elements, they having apparently died out. A number of forms not found in the basal beds appear. The number of dicotyledons is so much increased that they form the predominant plants. The most abundant ones are of more modern aspect than those of the basal beds and the characteristic archaic forms of the latter have mostly disappeared.

FOSSIL PLANTS FROM THE JAMES RIVER.

The following species occur in the collections from the banks of the James River, the only localities represented being those at Dutch Gap (see Monograph XV, p. 12) and Sailors Tavern (see ibid., p. 14):

Baieropsis pluripartita Font. ..... 1 specimen.
Dioonites Buchianus (Ett.) Born ..... 3 specimens.
Podozamites distantinervis Font.? ..... 1 specimen.
Sphenopteris latiloba Font. ..... 1 specimen.
Zamites tenuinervis Font.? ..... 1 specimen.

BAIEROPSIS PLURIPARTITA Fontaine.[a]

Pl. CVII, Fig. 1.

1889. *Baieropsis pluripartita* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 208, pl. lxxxix, fig. 4; pl. xc, figs. 2, 2a, 3, 4, 4a, 5; pl. xci, figs. 1, 3, 3a, 4, 7; pl. xcii, figs. 1, 2, 6.

DIOONITES BUCHIANUS (Ettingshausen) Bornemann.[b]

Pl. CVII, Fig. 2; Pl. CVIII, Fig. 1.

In 1895 Mr. Bibbins obtained from Sailors Tavern, for the Woman's College of Baltimore, two good specimens of *Dioonites Buchianus*, which are represented on Pl. CVII, Fig. 2, and Pl. CVIII, Fig. 1. This is a

[a] Professor Fontaine does not mention this plant in his report, although he returned the specimen so labeled. It was collected by himself at the entrance to Trents Reach below the Dutch Gap Canal in 1892. In a letter from him dated October 17, 1892, he says:

"I send you a small piece of shale containing a seeming drupaceous fruit, apparently attached by a short pedicel to the summit of the petiole of a leaf of Baieropsis, where the lamina of the leaf begins to divide. I should be glad if you would carefully examine and see if this is a real attachment and not an accidental location of the seed. If it is a real attachment, then we have for the first time found the fruit of Baieropsis, which in some points would resemble that of Ginkgo. The leaf is that of *Baieropsis pluripartita*, and comes from the entrance to Trents Reach. Please put the specimen in your collection. I found it since writing the description of the James River plants."

I do not find any reply to this letter, but I remember examining the specimen and concluding that the seed was not probably attached to the leaf by the side of which it occurs. It may, however, belong to this plant. Both the seed and the leaf are figured in Pl. CVII, Fig. 1.—L. F. W.

[b] For the synonymy of this species see pp. 244–245.

plant which is common at that locality and which was already known from that region, being described in Monograph XV, p. 182. The plant is characteristic of the lowest portion of the Lower Potomac of Virginia, the James River and Rappahannock series in the subdivisions of Professor Ward. The specimen represented on Pl. CVII, Fig. 2, is not numbered; that shown on Pl. CVIII, Fig. 1, is No. 5716 of the museum of the Woman's College of Baltimore.

One other leaflet of this plant occurs in a collection made by Mr. Ira Sayles from the Sailors Tavern locality on September 22, 1886.

FOSSIL PLANTS FROM ALUM ROCK.

The locality called Alum Rock is about 2 miles southwest of Fredericksburg. The material here that yields the fossils is a sandy shale, with very imperfect cleavage. It is near the base of the Lower Potomac, belonging to the lower portion of the Rappahannock or Fredericksburg series of strata. The fossils are few and poorly preserved, being mostly small fragments which can not be identified. The following species occur in the collection made by Messrs. Ward and White on May 3, 1892:

Carpolithus virginiensis Font. . . . . 1 specimen.
Cladophlebis alata Font. . . . . 1 specimen.
Cycadeospermum acutum Font. . . . . 1 specimen.
Pecopteris virginiensis Font. . . . . 3 specimens.
Sphenolepidium Sternbergianum densifolium Font. . . . . 1 specimen.

Mr. Bibbins also collected some specimens for the Maryland Survey from Alum Rock, but none of them are determinable.

FOSSIL PLANTS FROM THE 72D MILEPOST.

The locality designated "72d Milepost," on the Richmond, Fredericksburg and Potomac Railroad, which is a link in the Atlantic Coast Line system, is described in Monograph XV, pp. 19–20. The fossils found there were mostly in redeposited material, composed of clay lumps embedded in the sand in a short cut. The clay contained nearly all the plants. It must have been torn up and redeposited soon after its original deposition, so that both events belong to the same geological time. It belongs to the Aquia Creek series of Professor Ward's grouping of the Lower Potomac.

There are in the Maryland Survey collections a number of fossils credited to a locality given on the labels as "Railroad cut south of Aquia

Creek." The locality is not more precisely given, but it is probably that described in Monograph XV as "72d Milepost." The following plants occur in that collection:

Baieropsis pluripartita Font	16 specimens.
Sapindopsis brevifolia Font	5 specimens.
Sapindopsis magnifolia Font	1 specimen.
Sapindopsis variabilis Font	10 specimens.

No new forms not described in Monograph XV as found at this locality occur in the collection, and hence there is no reason for changing the conclusion drawn in that work for the age of the formation. The age was determined as Aquia Creek.

FOSSIL PLANTS FROM NEAR THE 72D MILEPOST.

On May 4, 1892, Professor Ward discovered a new plant locality, a short distance north of that of the 72d Milepost, at the end of the railroad cutting and below the tracks, on the west side. On July 28, 1893, I visited the place in company with Professor Ward and we made a collection larger than that made by him. The clay containing the plants shows its top in a drain below the level of the roadbed. It forms an undisturbed lens in the partially indurated sands. This clay no doubt represents a lens similar to that which was torn up to form the redeposited clay particles at the 72d Milepost. No plants were found here which had not previously been found in the same general region. The following is the list of species found here:

Aristolochiæphyllum crassinerve Font	8 specimens.
Baieropsis foliosa Font	3 specimens.
Glyptostrobus (Taxodium) brookensis (Font.) Ward	1 specimen.
Leptostrobus longifolius Font	1 specimen.
Sapindopsis magnifolia Font	1 specimen.
Sphenolepidium Sternbergianum densifolium Font	1 specimen.
Sphenolepidium virginicum Font	1 specimen.

ARISTOLOCHLÆPHYLLUM CRASSINERVE Fontaine.

Pl. CIX, Fig. 1.

1889. *Aristolochiæphyllum crassinerve* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 322, pl. clx, figs. 3, 3a, 4–6.

The large coarse leaves of *Aristolochiæphyllum crassinerve* occur in a considerable number of fragments. Some of them are larger and better

than those figured in Monograph XV, and one of these is figured in Pl. CIX, Fig. 1, to illustrate more fully the character of the plant. It is probable that an excavation in this clay and a more thorough collection would give more good specimens of this plant, which as yet is known only by portions of its leaves.

FOSSIL PLANTS FROM THE BANK NEAR BROOKE.

The locality designated "Bank near Brooke" (see Monograph XV, p. 21) represents strata of the Aquia Creek horizon or Brooke beds of the Lower Potomac, that have been fully described.

The following collections have been made from this locality since the appearance of Monograph XV:

1. A small collection by Lester F. Ward on June 20, 1891.

2. Another small collection by Lester F. Ward and David White on May 4, 1892.

3. Two slabs of considerable size containing numerous impressions of leaves and some well-preserved Unio shells were found so labeled without indication of collector or date. There is a memorandum in the register suggesting that they may have been collected by Fontaine, Knowlton, and Ward on the occasion of their visit to this place June 12–14, 1886.

4. A collection made for the Maryland State Geological Survey, not dated, but bearing the numbers 8304–8313 of that survey.

5. Three specimens collected for the same survey, bearing its number 8314 and the words: "Aquia Creek Bridge, Va., Loc. from L. F. Ward," which appear to be from the same locality, the rock material being the same and the same species occuring in it.

From all these sources the following species, with the number of specimens of each, are found:

Baieropsis foliosa Font	1 specimen.
Baieropsis pluripartita Font	6 specimens.
Leptostrobus foliosus Font	1 specimen.
Leptostrobus longifolius Font	4 specimens.
Menispermites virginiensis Font	3 specimens.
Sapindopsis brevifolia Font	2 specimens.
Sapindopsis magnifolia Font	1 specimen.
Sapindopsis variabilis Font	2 specimens.

As all of these species were previously known from this locality, and none of the specimens add anything to our knowledge of them, no special description of them seems necessary.

FOSSIL PLANTS FROM COCKPIT POINT.

Cockpit Point was not known to yield fossil plants until after the publication of Monograph XV. This locality is on the Potomac River. The Coast Line Railroad passes through a cut of considerable depth, situated immediately on the river. This cut has exposed an irregular clay lens inclosed in the Potomac sands and lying about 30 feet above the water. This lens is quite limited in extent, and where it is thickest is only about 2 feet thick. The material is a sandy clay, now hardened to a rough shale, with poor cleavage. It is not well adapted for the preservation of portions of plants of large size. As it is embedded in coarse sand and gravel, the water making the deposit was exposed to strong movements which tended to break up the fossils. This shale is full of plant remains and, if care is exercised, many identifiable forms may be obtained, although in small fragments.

In April, 1891, Mr. David White collected here two specimens showing traces of *Glyptostrobus* (*Taxodium*) *brookensis*. Some of the material from the cut was thrown on the bank of the river, and in this most of the fossils were obtained. The principal collections from this point was made by Professor Ward and myself in a single visit on July 27, 1893, lasting only an hour or so, with no expectation of finding fossils, hence it can not be taken as exhaustive. Indeed, under the circumstances, it is surprising that so many species, in such distinct forms, were found. Most of the fossils were collected from the dumped material, but some from the strata in place. As stated, the material is very unfavorable for the preservation of good specimens; still, a considerable number of plants, as may be judged from the following list, was obtained in the short time devoted to collecting them. Four specimens occur in the collections made by Mr. Bibbins for the Maryland State Geological Survey in May, 1897. The following is the list of species collected here. With the exception of Feistmantelia, none of them are new, having been described in Monograph XV.

Dioonites Buchianus (Ett.) Born	4 specimens.
Dryopteris heterophylla (Font.) Kn.	3 specimens.
Equisetum virginicum Font.?	2 specimens.
Feistmantelia virginica Font. n. sp	4 specimens.
Glyptostrobus (Taxodium) brookensis (Font.) Ward	2 specimens.
Nageiopsis heterophylla Font	1 specimen.

Nageiopsis longifolia Font.	1 specimen.
Nageiopsis microphylla Font.	4 specimens.
Nageiopsis obtusifolia Font.	1 specimen.
Scleropteris virginica Font.?	1 specimen.
Sphenolepidium dentifolium Font.	21 specimens.
Sphenolepidium Kurrianum (Dunk.) Heer?	2 specimens.
Sphenolepiduim parceramosum Font.?	1 specimen.
Sphenolepidium Sternbergianum densifolium Font.	1 specimen.
Sphenolepidium virginicum Font.	1 specimen.
Thyrsopteris decurrens Font.?	1 specimen.
Thyrsopteris densifolia Font.	1 specimen.
Thyrsopteris elliptica Font.	2 specimens.
Thrysopteris rarinervis Font.?	1 specimen.
Williamsonia? gallinacea Ward n. sp.	1 specimen.

FEISTMANTELIA[a] VIRGINICA Fontaine n. sp.

Pl. CVII, Fig. 3.

This plant occurs in four well-marked specimens. The characteristic cigar-shaped convexities are very distinct. There is no very good feature which may serve to determine, as distinct species, the specimens of this peculiar fossil, which have been found at widely separated localities. The specific name *virginica* is given to the plant from this locality to indicate the place of occurrence rather than its necessary specific independence.

Pl. CVII, Fig. 3, gives one of the most distinct of the specimens found. The four specimens in the collection are not to be taken as a measure of the abundance of the fossil at Cockpit Point, for a number of others could have been obtained.

[a] The genus Feistmantelia was named by me in my paper on the Cretaceous formation of the Black Hills (Nineteenth Ann. Rep. U. S. Geol. Surv., Pt. II, 1899, p. 693), founded on specimens collected by Professor Jenney in the Hay Creek coal field. In an extended note on pages 694–696 I set forth the grounds for thus treating it. Professor Fontaine was with me when I collected the specimens at Cockpit Point on July 27, 1894, and we discussed these objects together. In his description of the Hay Creek specimens, to which he gave no systematic name, he mentions those from Cockpit Point, but neither of us at that time ventured to assign to them a specific name. I did, however, name the Hay Creek form *Feistmantelia oblonga*, and the form figured by Feistmantel in the flora of Koch, *F. fusiformis*. We now have a third species, and the form from the Cheyenne sandstone of Kansas, mentioned in my note, will probably be a fourth, when the time arrives for treating it.—L. F. W.

WILLIAMSONIA? GALLINACEA Ward n. sp.[a]

Pl. CVII, Fig. 4.

The supposed Williamsonia is a fragment, showing what seems to be the summit of the peduncle of the inflorescence, with portions of the bases of the bracts. It is not distinct enough to make the generic identification positive.

The list given above of the plants obtained from Cockpit Point shows that the horizon is that of the Rappahannock or Fredericksburg beds; that is, near the base of the lower Potomac, corresponding to Professor Ward's Rappahannock series. This is confirmed by the character of the strata, for the fossiliferous stratum is, in lithological character, much like the basal material of the lower Potomac found at Alum Rock, near the town of Fredericksburg. It rests on unlaminated, greenish, sandy material which weathers bright red. This rock matter is characteristic of the bottom beds of the lower Potomac in the northern portion of the formation in Virginia.

FOSSIL PLANTS FROM NEAR WOODBRIDGE.

CYCADEOSPERMUM OBOVATUM Fontaine.

Pl. CVII, Fig. 5.

1889. *Cycadeospermum obovatum* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 270, pl. cxxxv, fig. 13.

Mr. Victor Louis Mason obtained on October 5, 1893, a complete seed of *Cycadeospermum obovatum* Font. from a cut on the Atlantic Coast Line Railroad below (south of) Woodbridge, Va., near the north end of the cut. This is from the same horizon as the plants from near Lorton, next to be considered. It occurs near the contact with the Cambrian slates. In Monograph XV these slates were spoken of as Azoic, but later investigations show them to be probably Lower Cambrian.

FOSSIL PLANTS FROM NEAR LORTON STATION.

This is the locality formerly known as "Telegraph Station." It was designated by this latter name in Monograph XV, p. 22. The railroad station is at Springman post-office. The spot from which the

[a] Professor Fontaine assigned no specific name to this form. The name adopted alludes to the locality.—L. F. W.

plants were obtained is a cutting on the Coast Line Railroad about 1 mile south of the station. The rock material yielding the plants is at the base of the Potomac, for the Cambrian slates may be seen outcropping a few feet beneath the stratum carrying the plants. The fossiliferous material is a buff to yellow shale, with good cleavage, which preserves the plants very well. It is nearly on the horizon of the Cockpit Point plants, but perhaps somewhat below that; both, however, belong to essentially the same geological horizon.

Two small collections have been made from this locality since the appearance of Monograph XV, one by Professor Ward and myself on July 26, 1893, and one by Professor Ward and Mr. Victor Mason on October 5, 1893. No new species occur in these collections, but they contain the following plants:

Acaciæphyllum microphyllum Font	3 specimens.
Dioonites Buchianus (Ett.) Born	9 specimens.
Dioonites Buchianus abietinus (Göpp.) Ward	1 specimen.
Dryopteris parvifolia (Font.) Kn	1 specimen.
Equisetum virginicum Font.?	1 specimen.
Glyptostrobus (Taxodium) brookensis (Font.) Ward	3 specimens.
Sequoia subulata Heer	3 specimens.
Sphenolepidium pachyphyllum Font	3 specimens.
Sphenolepidium Sternbergianum densifolium Font	2 specimens.
Zamites tenuinervis Font	1 specimen.

It will be seen from the enumeration of the specimens that the collection is a small one. The number of specimens, however, as in the case of the Cockpit Point fossils, is no measure of the abundance of the plants. After considerable search it was seen that, at both these localities nearly all the forms had been previously described, and hence no attempt was made to secure all the specimens. Only the best and most characteristic were collected. Still, the numbers given for the several species named in the list fairly represent their relative abundance in the flora.

Dioonites Buchianus abietinus (Göppert) Ward.[a]

Pl. CVIII, Fig. 2.

A very distinct specimen of *Dioonites Buchianus abietinus* is shown in Pl. CVIII, Fig. 2.

[a] For synonymy, etc., see p. 250.

FOSSIL PLANTS FROM THE COLCHESTER ROAD.

On August 5, 1893, Professor Ward obtained from the Colchester road in Virginia eight fragments of shale with traces of fossil plants. They are imprints of small portions of the ultimate pinnæ of a fern that resembles *Thyrsopteris pachyrachis* Font.,[a] a plant previously described from Virginia. There is not enough material sufficiently well preserved to positively determine the species. This is a species characteristic of the lower portion of the Lower Potomac, the part embraced in Professor Ward's two subdivisions, the James River series and the Rappahannock series. The exact locality from which these specimens were obtained is the right bank of Pohick Creek, on the west side of the Colchester road. This is a locality which at the time of the preparation of Monograph XV was not known to yield fossil plants.

FOSSIL PLANTS FROM WHITE HOUSE BLUFF AND MOUNT VERNON (BROOKE BEDS).

In the banks of the Potomac River called White House Bluff, and up the river to near the Mount Vernon Mansion, there are two different horizons containing fossil plants. The lower one is that of the Mount Vernon series of strata, on which Professor Ward found Mount Vernon plants at two localities. These will be noticed farther on (see p. 490). The upper one belongs to the Aquia Creek series or Brooke beds, and will be treated first because first discovered by me (see Monograph XV, pp. 22–23). Later Professor Ward discovered a locality of this age above the mouth of Doag Creek on the Mount Vernon estate. It will be convenient to treat both these localities under one head. Mr. William Hunter discovered in White House Bluff, near my original locality, a new locality for Aquia Creek plants. This is at the lower or south end of the large exposure next below the original locality and at nearly the same elevation above the water. These three localities for Aquia Creek plants may for distinction in this paper be called "Fontaine's locality," "Hunter's known locality," and "Ward's locality."

In 1895 Mr. Hunter collected a few specimens in this bluff from another locality, whose position was not given. These plants show

[a] Monograph XV, pp. 132, 133, pl. xlvi, figs. 3, 5; pl. xlvii, figs. 1, 2; pl. xlix, fig. 1.

that the horizon is that of the Aquia Creek series, but the matrix carrying the plants is somewhat different from that of the two localities given above. As it is on the same horizon its fossils may be noticed in this place and the locality be denoted as "Hunter's unknown locality."

The following collections have been made at these localities:

1. On November 6, 1892, a dozen or more small specimens of fossils belonging to the Aquia Creek or Brooke beds were collected by Lester F. Ward and Victor Mason on the Mount Vernon estate, in the bluff in which the Mount Vernon chocolate clays were first discovered and immediately over the principal plant bed in these clays.

2. On November 20, 1892, the same party collected half a dozen specimens from the original locality of Fontaine. It had suffered considerable alteration from caving and sloughing, and the specimens were taken from the extreme left (south end), under the roots of a tree.

3. On May 14, 1893, Mr. William Hunter, who had previously discovered the locality, guided the party above mentioned to what has been designated "Hunter's known locality," where between 30 and 40 specimens were obtained.

4. The same party visited on the same day the Mount Vernon bluff, where, besides the Mount Vernon plants, of which a large collection was made, they obtained one fine specimen from the immediately overlying Brooke beds. This locality is the same as No. 1, above.

5. A second smaller collection was made from the last-mentioned locality by William Hunter and Lester F. Ward on August 8, 1893.

6. Mr. Hunter made a collection of more than a dozen specimens from White House Bluff in 1895, the exact location of which was not stated on the labels. This is the one designated "Hunter's unknown locality."

The size of the collections made at the different localities varies much. This difference is due to the greater effort made to collect at some than at others. But little effort apparently was made to get additional specimens from Fontaine's locality, as a considerable amount of material had been obtained from it previously. Hence the number of specimens from this spot now to be noticed is very small. The specimens from Hunter's unknown locality are very few, probably because but a short time was devoted to securing them. A good many more were obtained from Ward's locality and from Hunter's known locality. From these facts the absence of specimens found at the two localities last named from the localities yielding the small collections does not necessarily imply their actual absence.

The following species were found at these localities:

Araucarites aquiensis Font.	1 specimen.
Baieropsis foliosa Font.	1 specimen.
Carpolithus brookensis Font.	2 specimens.
Celastrophyllum albædomus Ward n. sp.	1 specimen.
Ficophyllum eucalyptoides Font.	3 specimens.
Glyptostrobus (Taxodium) brookensis (Font.) Ward	13 specimens.
Glyptostrobus brookensis angustifolius (Font.) Kn.	5 specimens.
Glyptostrobus ramosus Font. n. comb. [Taxodium (Glyptostrobus) ramosum Font.]	1 specimen.
Sapindopsis magnifolia Font.	3 specimens.
Sapindopsis tenuinervis Font.	1 specimen.
Sapindopsis variabilis Font.	28 specimens.
Sequoia cycadopsis Font.	1 specimen.
Sphenolepidium Kurrianum (Dunk.) Heer.	1 specimen.
Sphenolepidium Sternbergianum densifolium Font.	3 specimens.

CELASTROPHYLLUM ALBÆDOMUS Ward n. sp.[a]

Pl. CVIII, Fig. 3.

GLYPTOSTROBUS BROOKENSIS ANGUSTIFOLIUS (Fontaine) Knowlton.

Pl. CVIII, Fig. 4.

1889. *Taxodium (Glyptostrobus) brookense angustifolium* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 256, pl. clxvii, figs. 1, 1a.

1898. *Glyptostrobus brookense angustifolium* (Font.) Kn.: Bull. U. S. Geol. Surv., No. 152, p. 112.

Five specimens of this plant were collected by Professor Ward and Mr. Mason in the light-colored clays that immediately overlie the original Mount Vernon plant bed and that belong to the Brooke horizon. The best of these is shown in Pl. CVIII, Fig. 4.

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[a] In my study of these collections mentioned above (p. 493) I provisionally identified this leaf with *Celastrophyllum Brittonianum* Hollick (Newberry, Flora of the Amboy Clays: Monogr. U. S. Geol. Surv., Vol. XXVI, p. 105, pl. xlii, figs. 37, 38, 46, 47), but did not describe it. Professor Fontaine returned it with the request that I treat it, as he was not acquainted with that species. A closer examination shows that it is not that species, but a new one. It may be described as follows:

Leaf ovate-lanceolate, rounded at the base and apex, unequal-sided, crenate-toothed, 4 cm. long exclusive of the petiole, which is wanting, 16 mm. wide at the middle; midrib strong and straight, secondary nerves camptodrome, delicate, curving forward, forking and anastomosing midway between the midrib and the margin, the branches forming festoons along the margins.

This pretty little leaf, perfect except the petiole, was collected on May 14, 1893 (see p. 494), at the locality previously discovered by Mr. William Hunter in the White House Bluff. The name alludes to the locality. The foundations of the former "White House" may still be seen on the bank of the Potomac at the foot of the bluff not far from the plant locality. This house was once a favorite resting place for fishermen and river men, and later a resort for excursionists from Alexandria and Washington, and the pavilion erected for dancing had not yet fallen in at the time of my first visit to the place.—L. F. W

It is somewhat remarkable that these should prove to be the only specimens occurring in the later collections treated in this paper. None were found at White House Bluff, where the original types were obtained and where the plant was the most common conifer.

FOSSIL PLANTS FROM THE MOUNT VERNON BEDS.

As intimated in the preceding account of the Aquia Creek plants of White House and Mount Vernon bluffs, the horizon of the Mount Vernon series of beds is below that of the Aquia Creek series. Prof. Lester F. Ward, who discovered this horizon, has given an account of it and of some of its plants in a paper entitled "The Potomac Formation."[a] This paper may be consulted for descriptions of the localities from which the collections of plants were made and of certain of the plants.

Collections were made from two localities on the Mount Vernon horizon. One of these is the White House Bluff, while the locality first discovered is higher up the river, above the mouth of Doag Creek. The latter locality, for distinction, may be called "Ward's first locality," while the other may be designated "Ward's second locality." The two localities are on exactly the same horizon. It should be stated that the first locality has yielded much the larger variety and quantity of plants.

The following is the history of the collections from these localities:

1. On October 16, 1892, Prof. Lester F. Ward discovered the principal locality, viz, that above the mouth of Doag Creek, on the Mount Vernon estate. The exact spot is opposite the site of the old Fairfax mansion and directly under the high point once known as Roses Delight.[b] Only a small collection was made on that day.

2. Professor Ward visited the locality on November 6, 1892, accompanied by Mr. Victor Louis Mason, prepared to make a much larger collection, in which they were successful.

3. The party last mentioned discovered the Mount Vernon chocolate clays in the White House Bluff on December 5, 1892. Only one specimen, however, was collected on this occasion.

4. On May, 14, 1893, Messrs. Ward, Mason, and Hunter made an excursion to both of these localities and brought back a large collection.

5. I accompanied Professor Ward to the original Mount Vernon locality on July 25, 1893. It was then much altered, the overhanging clay beds having fallen and buried it under talus. Only two specimens were obtained, as we had no facilities for uncovering the bed.

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[a] Fifteenth Ann. Rept. U. S. Geol. Surv., 1895 (see pp. 324–325, 348–366, pl. ii–iv).

[b] See Fifteenth Ann. Rep. U. S. Geol. Surv., 1895, p. 325.

6. Two specimens were collected on June 23, 1896, from the White House Bluff locality by Lester F. Ward and Charles Louis Pollard.

From all these collections the following species have been determined:

Antholithes Gaudium-Rosæ Ward	3 specimens.
Aralia ? vernonensis Font. n. sp	1 specimen.
Aristolochiæphyllum ? cellulare Ward n. sp	2 specimens.
Baieropsis denticulata angustifolia Font	2 specimens.
Casuarina Covillei Ward	1 specimen.
Celastrophyllum Brittonianum Hollick	1 specimen.
Celastrophyllum Hunteri Ward	2 specimens.
Celastrophyllum ? saliciforme Ward n. sp	1 specimen.
Cladophlebis rotundata Font	1 specimen.
Dryopteris virginica (Font.) Kn	4 specimens.
Ephedrites ? vernonensis Font. n. sp	1 specimen.
Ficophyllum crassinerve Font.?	1 specimen.
Glyptostrobus (Taxodium) brookensis (Font.) Ward	9 specimens.
Leptostrobus longifolius Font	3 specimens.
Menispermites tenuinervis Font	31 specimens.
Menispermites virginiensis Font	27 specimens.
Nageiopsis angustifolia Font	1 specimen.
Nageiopsis longifolia Font.?	1 specimen.
Pinus vernonensis Ward n. sp	3 specimens.
Populophyllum menispermoides Ward	24 specimens.
Populophyllum minutum Ward n. sp	1 specimen.
Populus auriculata Ward	9 specimens.
Populus potomacensis Ward	22 specimens.
Potamogetophyllum vernonense Font. n. sp	1 specimen.
Proteæphyllum reniforme Font	20 specimens.
Rogersia angustifolia Font	4 specimens.
Sagittaria Victor-Masoni Ward	1 specimen.
Scleropteris vernonensis Ward	15 specimens.
Sphenolepidium Sternbergianum densifolium Font	6 specimens.
Sphenopteris grevillioides Heer	7 specimens.
Sphenopteris latiloba Font	1 specimen.
Sterculia elegans Font.?	1 specimen.
Thinnfeldia variabilis Font	2 specimens.
Thyrsopteris bella Font	2 specimens.
Thyrsopteris decurrens Font.?	2 specimens.
Thyrsopteris rarinervis Font	6 specimens.
Zamia Washingtoniana Ward	11 specimens.

ANTHOLITHES[a] GAUDIUM-ROSÆ Ward.

Professor Ward has fully noticed[b] this peculiar plant, which is confined to the Mount Vernon locality, one specimen being found on the date of its discovery, October 16, 1892. Better specimens, including the form figured by Professor Ward, were obtained at the next visit to the locality, on November 6 of that year. The plant is rare, as only three specimens occur in the collections. He was fortunate in finding so good an imprint as that figured.

ARALIA ? VERNONENSIS Fontaine n. sp.

Pl. CVII, Fig. 6.

The Mount Vernon locality has yielded a single small leaf that seems to be a new species of Aralia. It is digitately divided into three lobes, which, measured across their summit, do not exceed 12 mm. The leaf is entire with the exception of the extreme base and petiole, which are missing. The length of the portion preserved is only 15 mm. It is hence a very small form. Of the nervation nothing can be made out except the midnerve, which divides as in Aralia into three branches, one for each lobe. The plant must have been extremely rare in this flora and its true position can not be positively made out. The specimen was collected November 6, 1892.

ARISTOLOCHIÆPHYLLUM ? CELLULARE Ward n. sp.

Pl. CVIII, Fig. 5.

A very peculiar leaf was obtained on November 6, 1892, from the Mount Vernon locality, consisting of two specimens broken up into numerous small fragments. The largest is that depicted in Pl. CVIII, Fig. 5. None of the fragments suffice to give any idea of the size and shape of the leaf. It was apparently a large leaf of thick, fleshy texture. It was probably rounded in form. The impressions show on their surface

[a] At the time (1894) my paper on the Potomac formation was written I supposed that the proper orthography of this genus was Antholithus, but thorough investigations since made have not been successful (as they were in the case of Carpolithus) in finding its use by any of the old authors. So far as at present known its first use was that of Brongniart in his "Classification" (Mém. Mus. Hist. Nat. de Paris, Vol. VIII, 1822, pp. 210, 320), where he writes it *Antholithes*. It is true that Brongniart here credits the name to Schlotheim, but the latter employed the longer name Anthotypolithes, and only for a form that he does not really describe and does not figure. It is also true that on p. 210 Brongniart treats his Antholithes as an order; still, on p. 238, he calls it a genus, and he names one species (*A. liliacea*), which he figures on pl. xiv [iii], fig. 7, and which must remain as the type of the genus.—L. F. W.

[b] Op. cit., pp. 354, 355, pl. iii, fig. 7.

a series of cell-like meshes, separated by narrow, raised, flat borders, which appear to be the nerves of the leaf. The specific name of the plant is founded on the cell-like character of the spaces between these nerves. The meshes cover the entire surface of the leaves. They are polygons made by the meeting, under large angles, of several sides. The number of the sides varies. They are mostly 5–8, but may occasionally be fewer. Their size also varies, some being twice as large as others. Within the meshes and grouped, radiating from a central point, are ridges or depressions, according to the relation of the fossil to the original leaf. Depressions seem to have existed originally in the leaf and these leave elevations in the clay embedding the leaf. The number of these radiating inequalities varies. They are mostly 5 or under. The concavities existing on the leaf seem to be puckers in its thick texture. There is apparently nothing like a differentiation of the nerves into grades, such as primary, secondary, etc. The flat, strong, cord-like margins or sides of the cells form the whole of the nervation. But some of the margins of the cells, corresponding in position and placed in the central line of the leaf, are so located as to seem to be continuations of one another and to form an irregular flexuous midrib. This, however, is accidental, and the margins of the meshes are the only nerves possessed by the leaf. The true position of this peculiar leaf is very problematical. It is placed with doubt in the genus Aristolochiæphyllum.

As indicated by Professor Ward, on the labels accompanying this plant, it has some resemblance to Heer's *Kaidacarpum cretaceum*,[a] but it is clearly not a fruit, as Heer considers that plant to be.

Celastrophyllum Brittonianum Hollick.[b]

Pl. CVII, Fig. 7.

1895. *Celastrophyllum Brittonianum* Hollick in Newberry: Flora of the Amboy Clays (Monogr. U. S. Geol. Surv., Vol. XXVI), p. 105, pl. xlii, figs. 37, 38, 46, 47.

1895. *Celastrophyllum Brittonianum* Hollick. Ward: The Potomac Formation (Fifteenth Ann. Rep. U. S. Geol. Surv., 1893–94), pp. 349, 358, 377, 378, 379.

[a] Fl. Foss. Arct., Vol. VII (Flora der Patootschichten), p. 19, pl. lxiv, fig. 9b.

[b] One of the specimens collected by me on my first visit to the Mount Vernon plant bed, October 16, 1892, seems certainly to be *Celastrophyllum Brittonianum* of Hollick, and agrees very closely with his figs. 38 and 47. The dentation extends somewhat farther down than that of any of the leaves figured by him, but this is scarcely a specific distinction. The exact shape of the base is not known, as it is unfortunately wanting, but the contraction begins at the same point and probably proceeded in the same way. From the very close resemblance I do not feel justified in separating it from that species, notwithstanding the difference in age, and this form may therefore be regarded as constituting one more of the few cases in which Older Potomac species persist into the Newer Potomac or Raritan formation.—L. F. W.

There is in the Mount Vernon collections a dicotyledonous leaf which Professor Ward on the label identifies with *Celastrophyllum Brittonianum*, a plant of the flora of the Amboy clays not known to me.

CELASTROPHYLLUM HUNTERI Ward.[a]

Pl. CVIII, Fig. 6.

1895. *Celastrophyllum Hunteri* Ward: The Potomac Formation (Fifteenth Ann. Rep. U. S. Geol. Surv., 1893–94), p. 358, pl. iv, fig. 9.

CELASTROPHYLLUM ? SALICIFORME Ward n. sp.[b]

Pl. CVIII, Fig. 7.

A single specimen of what is apparently a leaf of a dicotyledon different from all the rest was collected November 6, 1892, at the Mount Vernon locality. It is the imprint of the entire form, with, however, the margins not preserved in all places. It is linear oblong in form, with a great length in proportion to its width. The general shape is that of a willow. It resembles also *Rogersia angustifolia*, but the margins of the middle and terminal portions have small acute teeth. The midnerve is distinct and maintained to near the end of the leaf. The lateral nerves can hardly be made out and must have been slender. They seem to leave the midrib at an angle of about 45° and, about the middle of the lamina, to bend sharply toward the tip of the leaf. The precise position of this form is doubtful, and it is placed with hesitation in the genus Celastrophyllum.

[a] On May 14, 1893, our party collected two lanceolate dicotyledonous leaves in the Mount Vernon chocolate clays at the White House Bluff locality. One of these I used as the type of the new species *Celastrophyllum Hunteri*. The other I then regarded as different and did not name. I compared it with *C. Brittonianum*, but it does not very closely resemble that species, being much larger, more elongate, and different in nervation. In fact, the nervation is nearly the same as that of the type of *C. Hunteri*, but the shape is somewhat different. Further study of both specimens convinces me that they belong to the same species. The second leaf is here figured for the first time. It has the following character:

Leaves lanceolate, widest below the middle, narrowing more rapidly near the apex, acute at the tip, 15 mm. to 20 mm. wide, probably 7 cm. long, but basal portion wanting in both the specimens known, finely and sharply dentate with shallow teeth; nervation pinnate, craspedodrome, the secondaries nearly straight, leaving the midrib at a very sharp angle, slender, alternate, usually once forking, often below the middle but sometimes near the margin, the branches entering the teeth; midrib relatively strong, central, straight, or somewhat curved.—L. F. W.

[b] The specific name given by Professor Fontaine was preoccupied. The one substituted here relates to the elongate willow-like form of the leaf.—L. F. W.

EPHEDRITES ? VERNONENSIS Fontaine n. sp.

Pl. CVII, Fig. 8.

The Mount Vernon locality yielded a pair of small nut-like seeds that seem to have been closely approximate in growth. On the inner side, where they touched each other, they have nearly straight margins. On the outer side the margins are curved. At their bases they are rounded and obtuse. At their summits they are acute. They seem to have been covered by a small leaf or scale. They do not stand out convex on the matrix, and hence were probably thin in texture. They resemble the paired seeds from the Jurassic of Siberia, described by Heer as *Ephedrites antiquus*.[a] Of course the amount of material is not sufficient to fix the position of these seeds, but they may provisionally be placed in the genus Ephedrites.

The specimen was collected on November 6, 1892.

GLYPTOSTROBUS (TAXODIUM) BROOKENSIS (Fontaine) Ward.

Pl. CX, Fig. 1.

1889. *Taxodium* (*Glyptostrobus*) *brookense* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 254, pl. cxxii, figs. 1, 1a, 1b; pl. cxxiv, figs. 3, 3a, 4, 4a, 5–7, 7a, 8, 9; pl. cxxxi, figs. 5, 5a; pl. clxv, figs. 1–3; pl. clxvi, figs. 4, 4a, 7; pl. clxvii, fig. 3.

1895. *Glyptostrobus brookensis* (Font.) Ward: Fifteenth Ann. Rep. U. S. Geol. Surv., 1893–94, p. 359.

There are 9 specimens of this conifer in the Mount Vernon flora. Some of them are very fine. The specimen given in Pl. CX, Fig. 1, is one of the best of these. The leaves on the ultimate branches are beautifully preserved. This is due to the fineness of texture of the matrix of the Mount Vernon clay. One of the finely preserved specimens has associated with it a cone that seems to be an immature female one, belonging to this plant. It is, however, not certainly attached to a twig. The cone is oblong in shape, about 7 mm. long, with faintly shown scales that seem to be chaffy.

The specimens were all found at the Mount Vernon locality, most of them, including the one figured, on November 6, 1892, but some on October 16, 1892, and two on May 14, 1893.

[a] Fl. Foss. Arct., Vol. IV (Beitr. z. Jura-Fl. Ostsibiriens), p. 82, pl. xiv, fig. 7.

Menispermites tenuinervis Fontaine.

Pl. CIX, Figs. 2, 3.

1889. *Menispermites tenuinervis* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 322, pl. clxxii, fig. 8.

1895. *Menispermites virginiensis* Font. Ward: Fifteenth Ann. Rep. U. S. Geol. Surv., 1893–94, p. 360,[a] pl. iv, fig. 7.

No fewer than 31 specimens referable to this species occur in the collections from the Mount Vernon beds. All but three are from the Mount Vernon locality, but these three were found at White House Bluff. These specimens represent a plant which appears to be specifically different from *M. virginiensis*. This latter is not rare in the collections, and differs in several important points from the plant now in question. As given in Monograph XV, a small Menispermites, described as *M. tenuinervis*,[b] was found very rarely on Jackson, formerly Belt street, Baltimore, Md. The specimens found in Baltimore were very rare, and mostly small fragments. The most complete leaf, given in fig. 8, showed fully a portion of the three primary nerves. The size of the leaves and the delicate nervation of the Mount Vernon specimens are points that agree with the Baltimore plant, and make it probable that the specimens belong to *M. tenuinervis*. These leaves differ markedly from those of *M. virginiensis*, since they are generally much smaller. The nervation is also much more delicate. This was probably the case with the Baltimore plant, and hence the difficulty of seeing its nervation. The fine clay of the Mount Vernon localities is exceptionally well fitted to show delicate details, otherwise the minor nervation would probably be inconspicuous in these specimens also. The small leaf given as *M. virginiensis* in pl. iv., fig. 7,[c] of Professor Ward's Mount Vernon flora[d] is probably this species. The contrast between this leaf and the one represented in fig. 8 of the same plate illustrates well the difference between

[a] From the statement here made it seems that Professor Fontaine, to whom some of the Mount Vernon material was submitted at that time, himself referred both these leaves to his *M. virginiensis*. The difference may not be specific.—L. F. W.

[b] Monograph XV, p. 322, pl. clxxii, fig. 8.

[c] The Potomac formation: Fifteenth Ann. Rep. U. S. Geol. Surv., 1895, pl. iv, fig. 7.

[d] Through inadvertence the counterpart of this specimen was drawn for this paper, and is represented on Pl. CIX, Fig. 2. In view of the fact that Professor Fontaine refers this specimen to *M. tenuinervis* it may be well to retain the figure. It shows the lower side of the leaf, where the raised nerves are more distinct than they are on the upper side.—L. F. W.

this species and *M. virginiensis*. The size of the leaves varies somewhat. An average size is represented in Pl. CIX, Fig. 2, which gives a nearly complete leaf with the basal part well preserved. This was probably a leaf not quite 6 cm. wide and a little more than 5 cm. long. This is probably a leaf not of normal shape, for the transverse diameter in these leaves was probably greater than the vertical, giving a subreniform shape. Professor Ward has written on the label of another specimen of Menispermites in the Mount Vernon collections the name *M. reniformis* Dn. This too is probably *M. tenuinervis*, but it was a leaf above the normal size, as it was probably about 7 cm. in its transverse and greater diameter. This leaf is represented in Pl. CIX, Fig. 3.

The material available for description in Monograph XV did not permit a full determination of the plant. We may, with the help of the Mount Vernon specimens, add the following to its description:

The leaves were mostly small, rotundate, or subreniform in shape, with the transverse diameter the greater, attaining a maximum of 7 cm. The margin was entire or slightly undulate. The texture was thin. The nerves of all orders are slender. The divergence of the principal nerves takes place from a point within the lamina of the leaf, but nearer the base than in the leaf of *M. virginiensis*. The general plan of the nervation and the mode of its division are similar to those points in *M. virginiensis*.

Pinus vernonensis Ward n. sp.[a]

Pl. CIX, Figs. 4–6.

A single specimen of a small winged seed was obtained in the Mount Vernon collections. It was named by Professor Ward, on the label, *Pinus vernonensis*, but no description was given. It does not seem to be the same seed as *P. schista*. It is, in the seed proper, of about the same shape

[a] Three winged seeds occur in the collections, all collected on November 6, 1892, at the Mount Vernon locality, two of them in counterparts, which I had named as above before sending the collections to Professor Fontaine. He found only two of these, one of which he was disposed to identify with the species from Rosiers Bluff (see p. 530), but remarked that the wing was not cleft, which is the leading character of that species. The other he labeled with the name I had given it. I can not see that these seeds differ specifically and will, therefore, include them all under this species, which has the following character:

Seeds small, 12 mm. long, the wing 9 mm. long, 5 mm. wide above the middle, rounded at the apex, narrowing toward the point of attachment, the sides unequally curved, finely striate; the seed proper 5 mm. long by 3 mm. wide.—L. F. W.

as *P. schista,* but is rather larger. The wing, however, is elliptical in form, and not divided as in that plant. It may be *P. schista,* as the amount of material is not sufficient to determine its true character.

POPULOPHYLLUM MENISPERMOIDES Ward n. sp.

Pl. CX, Figs. 2–4.

Professor Ward has indicated, on labels accompanying it, a plant of the Mount Vernon flora as a new species, with the name given above. As no description accompanies it, the description may be given here. The plant is quite common on the Mount Vernon horizon, and a number of specimens were obtained. They are chiefly fragments of leaves, mostly small and imperfect. The specimen shown in Pl. CX, Fig. 2, from the White House Bluff locality, may be taken as the type. It shows the dentation better than the others. The specimens depicted in Figs. 3 and 4 are the best obtained. Fig. 3, from the Mount Vernon locality, gives fragments of leaves, showing the central parts from base to summit, but with the right and left margins missing. By taking the missing parts from other specimens a pretty good idea of the complete leaf may be formed. The length indicated is 4 cm., and the width was probably greater. Its shape seems to have been subreniform, being wider than long. The margin was entire, or at most had shallow crenate teeth. The principal nerves radiate from a common point at the base of the leaf and the summit of the petiole. The middle nerve is stronger than those on either side. These principal nerves split up, after the fashion of those of Menispermites, into secondary ones. These curve to join adjacent ones of the same order, forming large, more or less rounded, meshes. The secondary nerves send off tertiary ones at nearly right angles, and these unite to form rounded meshes. The minor nervation is a good deal like that of Menispermites. The most important difference in the nervation from Menispermites is the fact that the primary nerves radiate from the summit of the petiole at the base of the leaf and not within the lamina. The plant shown in Fig. 3 gives the nerves distinctly. Fig. 4, also from the Mount Vernon locality, shows a nearly complete leaf smaller than the average.

This species seems to be specially characteristic of the White House Bluff locality, the same number (12) of specimens occurring from there as in the Mount Vernon collection, notwithstanding the much greater size of the latter. The first and only specimen brought from the former

locality at the time of its discovery, on December 5, 1892, is a good example of this plant and occurs in counterparts. This is the one shown in Pl. CX, Fig. 2. The other specimens from this locality were collected on May 14, 1893. Of those from the Mount Vernon locality 1 good specimen was obtained on the occasion of its discovery by Professor Ward, on October 16, 1892, 8 on the next visit, November 6, 1892, including the one represented in Fig. 3, and 3 on May 14, 1893, including that shown in Fig. 4.

Populophyllum minutum Ward n. sp.[a]

Pl. CVII, Fig. 9.

Professor Ward has, on the label accompanying it, compared one small specimen from the Mount Vernon locality with Velenovsky's *Cissites crispus*. The leaf resembles *Populus potomacensis* in shape and size, but the nerves are different. The specimen was collected on November 6, 1892, and occupies the opposite side of the most complete counterpart of *Celastrophyllum Brittonianum* treated above.

Populus auriculata Ward.

Pl. CX, Fig. 5.

1895. *Populus auriculata* Ward: The Potomac Formation (Fifteenth Ann. Rep. U. S. Geol. Surv., 1893–94), p. 356, pl. iv, fig. 4.

This species was first found by Professor Ward, and was described by him. The form given in Fig. 4 of his paper is one of the best

[a] Professor Fontaine returned this specimen without description with the request that I describe it. It has the following character:

Leaf nearly circular in outline, very small, about 16 mm. in length and breadth, coarsely dentate except near the base; nervation somewhat palmate, but central nerve much stronger than the four lateral ones that proceed from the summit of the petiole, these latter forking and anastomosing some distance from the margin and giving off fine nervilles that cross the meshes irregularly.

The nervation of this little leaf is in some respects similar to that of the Vitaceæ, but there are features that recall Populus. It may represent a small form of that genus. It can not, however, be referred to either of the species of Populus from the Mount Vernon clays, and is a new species. I place it for the present in the extinct genus Populophyllum, its nearest affinities being perhaps with *P. reniforme* Font.

The note that I made on the label at the time I studied this collection is as follows: "This leaf is a Cissites near *C. crispus*, probably the same as that figured by Doctor Newberry (Flora of the Amboy Clays, pl. xlii, figs. 20–23), but not identical with Velenovsky's species." I have not seen the Amboy clay specimens, much less the specimen figured by Velenovsky, but judging from the figures on second inspection I would now recede from the statement in my note. The type of *C. crispus* from the Cenomanian (Chlomeker Sandstein) of Böhm-Leipa in Bohemia (see Velenovsky, Die Flora der böhmischen Kreideformation, Pt. IV, p. 12, pl. iv, fig. 6; Beiträge z. Paläontologie Österreich-Ungarns, Vol. V, Heft I, p. 73, pl. xxvii, fig. 6) is a very different thing from Doctor Newberry's plant. My specimen is nearest to his fig. 20. It also resembles his fig. 22, but that is much smaller. His figs. 21 and 23 are not only different specifically from these, but also from each other. I do not think that Doctor Newberry's plant is a Cissites.—L. F. W.

found, the rest being generally small fragments of leaves. This seems to be correctly separated from *Populus potomacensis* by Professor Ward. It is rarer than the latter, only 9 specimens having been found. It is confined to the Mount Vernon locality. Pl. CX, Fig. 5, gives a proportionally broader form than that figured by Professor Ward. This specimen occurs in counterparts, and was collected on May 14, 1893, along with two others. Of the 5 specimens obtained on November 6, 1892, this one is that figured by Professor Ward.

POPULUS POTOMACENSIS Ward ?.

This beautiful little leaf was first found by Professor Ward, and it was fully described by him.[a] It is very abundant in the Mount Vernon strata, and in fact seems to be practically confined to them, so that it may be regarded as their most characteristic fossil. A number of leaves may be found nearly or quite entire. This is surprising when we consider their delicate texture, but the fact may be explained by their very small size.

All but three of the specimens were found at the Mount Vernon locality, that represented by fig. 1 of Professor Ward's paper being one of those collected by him on his first visit, on October 16, 1892. His fig. 3 represents a specimen that occurs on the reverse of one of the counterparts of the type specimen of *Antholithes Gaudium-Rosæ*, collected on November 6, 1892, and his fig. 2 represents one of the few specimens that were taken on the occasion of my visit to the locality, under his guidance, on July 25, 1893. It shows the maximum size.

Genus POTAMOGETOPHYLLUM[b] Fontaine nov. gen.

The true position of this genus can not be determined from the material at hand, and the generic name is chosen only to indicate its resemblance to Potamogeton in points that may not be essential.

POTAMOGETOPHYLLUM VERNONENSE Fontaine n. sp.

Pl. CIX, Fig. 7.

A very rare leaf, resembling Potamogeton, occurs in the Mount Vernon collections, one specimen only being found in counterparts. It

[a] Op. cit., pp. 355, 356, pl. iv, figs. 1–3.

[b] As the second component (*γείτων*) of the name Potamogeton is itself derived from *γέα*, *γῆ*, and its immediate derivative, *γήτης*, this shortened form, which drops the characteristic *n*, is fully justified.—L. F. W.

occurs on the same slab and by the side of the fine specimen of *Glyptostrobus brookensis* shown on Pl. CX, Fig. 1, collected on October 16, 1892, at the Mount Vernon locality. The specimen is a fragment 45 mm. long, which is depicted in Pl. CIX, Fig. 7. Its maximum width, which is at one end, is 16 mm. This widest portion seems to be the middle part of the leaf. It narrows toward the opposite end, but the true termination does not seem to be preserved. When entire, the leaf was probably narrowly elliptical in form. It looks somewhat like a Rogersia, but does not have the nervation of that plant. So far as it can be made out, the nervation is peculiar. At the wider end, and for some distance toward the narrower, there is an imprint along the central line of the leaf that may represent a midrib, but it is ill defined, and seems to be composed of several slender nerves that were loosely united, and which now, under the pressure to which the leaf has been subjected, have become separated in a straggling manner. Before reaching the narrow end of the leaf the apparent midnerve abruptly ends, seeming to split up. The other nerves, on each side of the ones just described, are faint and irregular, and their course can not be certainly made out. They seem to run approximately parallel with the central nerve and to anastomose, forming long straggling meshes. The plant is very rare.

Scleropteris vernonensis Ward.

Pl. CVII, Fig. 10.

1895. *Scleropteris vernonensis* Ward: The Potomac Formation (Fifteenth Ann. Rep. U. S. Geol. Surv., 1893–94), p. 349, pl. ii, figs. 1, 1a, 2, 3.

Professor Ward in his paper on the Potomac formation, page 349, has described this plant, and on pl. ii, figs. 1, 1a, 2, 3, has figured some of the forms. The specimen depicted in fig. 3 is the largest one found. Thirteen other scattered fragments occur in the Mount Vernon collections, but they are mostly small bits of ultimate pinnæ, showing at most a few pinnules. The texture of the pinnules is thick and leathery, so as to hide the nerves. In fig. 1, 1a, enlarged, Professor Ward has given a form of this plant which differs from the normal, and which is apparently its fructified form. One specimen, depicted on Pl. CVII, Fig. 10, occurs, which is larger than the minute specimen given by Professor Ward in fig. 1, and which indeed is nearly as large as the magnified figure.

The pinnules are narrowed toward the base and are expanded toward the apex, mostly into two round lobes. A nerve passes into the base of the pinnule and splits into two branches, one going into each lobe. The branch in the upper lobe bears at its summit a club-shaped sorus. These fructified forms are very rare.

Eight of the specimens of this plant were found at the White House Bluff locality on May 14, 1893, and these include the largest ones, the finest one being that represented by Professor Ward's fig. 3. The rest were collected at the Mount Vernon locality on November 6, 1892, and those represented by his figs. 1 and 2 are from there. The specimen now figured (Pl. CVII, Fig. 10) is from White House Bluff and occurs in the same collection as the large one figured in the Fifteenth Annual Report.

STERCULIA ELEGANS Fontaine ?.

Pl. CX, Fig. 6.

1889. *Sterculia elegans* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 314, pl. clvii, fig. 2; pl. clviii, figs. 2, 3.

Sterculia elegans is a plant found at Deep Bottom, on James River, on the horizon of the Aquia Creek group. It may be present at the Mount Vernon locality, represented by a single specimen collected November 6, 1892. This is a fragment of a leaf showing its basal portion and a part of the petiole. In the leaf there are two main nerves diverging from the top of the petiole. No central nerve, if ever present, is now visible. Possibly the plant may be a Bowenia.

THINNFELDIA VARIABILIS Fontaine.[a]

Pl. CX, Figs. 7, 8.

1889. *Thinnfeldia variabilis* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 110, pl. xvii, figs. 3, 3a, 4, 4a, 5–7; pl. xviii.

This is a very rare fossil in the Mount Vernon beds. Only two specimens, showing small bits of ultimate pinnæ, were obtained, both from the White House Bluff locality, on June 23, 1896.

[a] On the label Professor Fontaine queries the reference of these specimens to *T. variabilis*, but in his manuscript he makes the reference positive. They were the only specimens I was able to find at the White House Bluff locality when I visited it in company with Mr. Charles L. Pollard on June 23, 1896, or nearly three years after the principal collection was made. In my notebook I record that the conditions were much changed by washing, and it is probable that the spot where the ferns were found was several feet farther in the bluff than the original bed. As this fern was not found in the much larger collection previously made, and does not seem to occur at the Mount Vernon locality, the finding of these specimens thus isolated is somewhat singular.—L. F. W.

Zamia Washingtoniana Ward.[a]

Pl. CXI, Figs. 1, 2.

1895. *Zamia Washingtoniana* Ward: The Potomac Formation (Fifteenth Ann. Rep. U. S. Geol. Surv., 1893–94), p. 350, pl. ii, fig. 6.

Professor Ward, in the work cited, has given an account of this plant, and in pl. ii, fig. 6, has depicted a leaflet and what he regards as its fruit. In his description of the leaflet he regards the narrowed portion as the base. In my opinion this is a mistake, it being the termination of the leaf. Several other fragments of the leaflets of this plant were obtained. One of them shows the base pretty well preserved. It narrows like Zamites and seems to have been articulated to the stem. This is indicated also by the fact that all the leaflets are detached. Some of the leaflets must have been very large, much surpassing any leaflet of like form found previously in the Potomac flora. Several of the fragments show a maximum width of 15 mm. One fragment, apparently a little more than half of a leaflet, is 16 cm. long. A smaller, entire leaf, probably from the upper part of the component leaf, was obtained which is only 11 cm. long. This is much smaller than most of the leaflets found. This shows the base slightly narrowed and also thickened. The nerves are not very distinct in the leaflets of this plant. They appear to be comparatively broad and flat. Eleven specimens of this plant occur in the collections, all from the Mount Vernon locality. Six of these were collected on November 6, 1892. These are all small fragments. The remaining five, collected on May 14, 1893, include all those figured and two less complete leaves.

The above comprise all the fossils found in the Mount Vernon beds up to the present time, 39 species in all. There is little doubt that a good many more might be found in them if sustained search were made. They are sufficient to show that this horizon is, as Professor Ward maintained, an intermediate one between the Rappahannock and the Aquia Creek beds.

[a] Two other fine specimens of leaves of this plant, both in counterparts, were found at the same time and place as the one figured by me, and in view of Professor Fontaine's statements I thought best to figure them. The broad one represented in Pl. CLXXVI, Fig. 1, is typical, but shows the complete tip drawn out to a long, narrow, curved point. The other, shown in Fig. 2, is a much narrower leaf, and I was in doubt whether it belonged to the same species. Professor Fontaine returns it without comment, with the name on the label as I had written it. I therefore conclude that he considers it a narrow form of this plant. This also shows the tip complete. The crooked shape of the leaf must be ascribed to distortion from pressure.—L. F. W.

FOSSIL PLANTS FROM HELL HOLE.

[Pl. LXXX, No. 147.]

On April 7, 1896, Mr. Arthur Bibbins collected for the Maryland Survey a considerable number of fossil plants from a locality called Hell Hole, on the Virginia side of the Potomac River. This locality is between Mount Vernon and White House Bluff, but some distance above Professor Ward's locality. Most of the rock matter is grayish chocolate-colored, arenaceous clay, which preserves the plants fairly well. Some is a chocolate clay. The following is the list of fossils obtained here:

Aristolochiæphyllum crassinerve Font.	2 specimens.
Athrotaxopsis expansa Font	2 specimens.
Baieropsis foliosa Font	9 specimens.
Baieropsis longifolia Font	1 specimen.
Baieropsis pluripartita Font	3 specimens.
Carpolithus virginiensis Font.	1 specimen.
Celastrophyllum brookense Font.?	2 specimens.
Cladophlebis constricta Font.?	2 specimens.
Ficophyllum tenuinerve Font.?	6 specimens.
Frenelopsis ramosissima Font.?	1 specimen.
Leptostrobus longifolius Font.	1 specimen.
Menispermites virginiensis Font.?	3 specimens.
Onychiopsis psilotoides (Stokes & Webb) Ward	3 specimens.
Sassafras bilobatum Font.?	1 specimen.
Sequoia ? inferna Ward nom. nov.	2 specimens.
Sphenolepidium Sternbergianum densifolium Font.	19 specimens.
Thyrsopteris divaricata Font.?	1 specimen.

BAIEROPSIS FOLIOSA Fontaine.

Pl. CX, Fig. 9.

1889. *Baieropsis foliosa* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 209, pl. xciii, figs. 4, 4a, 5, 6, 6a.

Nine specimens of this species occur at Hell Hole, but even the best of them contain only a small portion of the plant. This is a species highly characteristic of the Aquia Creek horizon in Virginia. The specimens from Hell Hole show laciniæ even more slender than the Virginia forms. Pl. CX, Fig. 9, gives one of these. It bears the number M. G. S., 8431.

BAIEROPSIS LONGIFOLIA Fontaine.

Pl. CXI, Fig. 3.

1889. *Baieropsis longifolia* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 210, pl. xci, fig. 6.

This plant, it is true, is represented by only one specimen, but this is a well-characterized one, showing a segment with several subdivisions of such a length as to indicate a leaf of great size. The segment is 7 cm. long, with a portion of the length wanting. This may be a form of *Baieropsis pluripartita*, but it agrees closely with the plant described as *B. longifolia* from the Rappahannock beds near Telegraph station, now Lorton. This latter, however, may be *B. pluripartita* in a form longer and with laciniæ more slender than usual. The imprint is on the specimen numbered M. G. S., 8448.

BAIEROPSIS PLURIPARTITA.[a]

B. pluripartita shows at least one specimen with two segments that can not be mistaken. The other two specimens are not so distinct. It does not seem to have been common at Hell Hole, while it is an important fossil in the Rappahannock member of the Lower Potomac of Virginia. It also may be regarded as a survivor.

CELASTROPHYLLUM BROOKENSE Fontaine?

Pl. CX, Fig. 10.

1889. *Celastrophyllum brookense* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 305, pl. clviii, fig. 8; pl. clix, fig. 7.

There are in the collection two specimens of a dicotyledon that is probably *C. brookense*, but they can not be positively determined. Pl. CX, Fig. 10, gives the best specimen, which is the end of a leaf. The nerves are not fully shown. It is, in any case, a dicotyledon of more modern aspect than the archaic ones that characterize the Rappahannock member of the Lower Potomac of Virginia. The specimen figured is numbered M. G. S., 8466, and the duplicate 8445.

[a] Monograph XV, p. 208, pl. lxxxix, fig. 4; pl. xc, figs. 2–5; pl. xci, figs. 1, 3, 4, 7; pl. xcii, figs. 1, 2, 6.

LEPTOSTROBUS LONGIFOLIUS Fontaine.

Pl. CX, Fig. 11.

1889. *Leptostrobus longifolius* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 228, pl. ci, figs. 2, 3; pl. cii, figs. 1–4; pl. ciii, figs. 6, 6a–6e, 7, 8, 8a, 9–12; pl. civ, fig. 6.

In the collection occurs one specimen of *Leptostrobus longifolius* which shows leaves attached to a portion of a stem. These show a peculiar broadening at the base, where attached, which is probably due to distortion from pressure. Pl. CX, Fig. 11, is given to show this. The impression occurs on the rock specimen, No. 8431, with other species.

ONYCHIOPSIS PSILOTOIDES (Stokes & Webb) Ward.[a]

Pl. CXI, Fig. 4.

This plant is of much importance in this collection. Pl. CXI, Fig. 4, gives the best of the three specimens found. It is a portion of a penultimate pinna with a number of ultimate ones, carrying well-characterized pinnules. The imprints are all on a single slab in counterparts, the part bearing the one figured being No. 8428 and the counterpart No. 8430 of the Maryland Geological Survey.

This fern is more characteristic of the Rappahannock than of the Aquia Creek horizon.

SASSAFRAS BILOBATUM Fontaine.?

Pl. CXI, Fig. 5.

1889. *Sassafras bilobatum* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 290, pl. clvi, fig. 12; pl. clxiv, fig. 4.

There is in the collection a fragment of a leaf of considerable size which is of problematic character but which in some points resembles *Sassafras bilobatum* from the Aquia Creek horizon of the Virginia Lower Potomac. It is, however, too poorly preserved to permit its true character to be made out. It is most like the form given in Monograph XV, pl. clxiv, fig. 4, but the fragment indicates a leaf larger than the one

[a] For synonymy of this species see pp. 155–156..

given in that figure. The original margin of the leaf is retained only in the left-hand upper portion. Here there is an indication of a rather shallow lobe, in which ends a secondary nerve that is considerably stronger than any of the others sent off from the midrib. The latter is rather slender for a leaf of this size and ends in what appears to be a terminal lobe, which is only partially preserved. The right-hand margin of the leaf is not preserved, so that if a lobe once existed on that side it is not visible now. That none such existed is indicated by the fact that no strong secondary nerve is sent off on that side corresponding to the one on the left-hand side, which ends in the lateral lobe. The sinus made by the left lobe with the terminal lobe is more open than that found in *S. bilobatum* figured on pl. clxiv of Monograph XV, and indeed it is more like that of a Liriodendron. The specimen is No. 8437 of the Maryland Geological Survey.

SEQUOIA ? INFERNA Ward nom nov.[a]

1889. *Sequoia* species ? Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 248, pl. cxvi, fig. 7; pl. cxxxii, figs. 2, 5, 6.

There are in the collection two dissected cones with a few scales attached that exactly resemble the specimens described in Monograph XV as "Sequoia species ?" and figured on pl. cxxxii, in figs. 2, 5, 6. This is a very well characterized cone, easily distinguished from any other. It is known to occur only in the Aquia Creek beds, and although it can not be assigned to any species founded on leafy branches, and hence was left undetermined, it is none the less of value in indicating the age of the strata containing it. The specimens bear the numbers M. G. S., 8 54, 8465.

SPHENOLEPIDIUM STERNBERGIANUM DENSIFOLIUM Fontaine.

Pl. CXII, Fig. 1.

1889. *Sphenolepidium Sternbergianum densifolium* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 261, pl. cxviii, fig. 7; pl. cxxi, figs. 5, 5a, 5b, 7, 7a, 9, 9a; pl. cxxv, figs. 2, 2a, pl. cxxix, fig. 3; pl. cxxx, figs. 1, 1a; pl. cxxxi, figs. 1, 1a–1c, 3, 3a; pl. cxxxii, figs. 4, 4a.

[a] These, as Professor Fontaine says, are well-characterized cones and scales, recognizable wherever found, and therefore of diagnostic value in determining age. The fact that they can not be identified with species known by the foliage does not seem to be a sufficient reason for not assigning to them a specific name. The name adopted relates to the locality now being treated.—L. F. W.

This furnishes the largest number of specimens, 19 in all. Some of them are beautifully preserved. Pl. CXII, Fig. 1, gives one of these distinct forms. This fossil belongs to both the Rappahannock and the Aquia Creek horizons, being most common in the latter. The specimen figured is No. 8452 of the Maryland Survey, and its counterpart is No. 8444.

FOSSIL PLANTS FROM THE MOUTH OF HELL HOLE.

[Pl. LXXX, No. 147.]

Another spot in the same vicinity is called "Mouth of Hell Hole." On the same day Mr. Bibbins collected here the following plants:

Baieropsis foliosa Font.?	4 specimens.
Celastrophyllum obovatum Font.?	1 specimen.
Sphenolepidium Sternbergianum densifolium Font	4 specimens.

All the species found at the Mouth of Hell Hole are also found at the principal locality with a larger number of specimens, so that they do not indicate a different horizon.

The plants found at these two localities do not make it entirely clear whether they belong to the Mount Vernon or the Aquia Creek horizon. It is true that there is a considerable proportion of the plants occurring on the Rappahannock horizon found here, but they appear rather to be survivors than dominant forms. Some, such as the *Sequoia? inferna*, the *Aristolochiæphyllum crassinerve*, the dicotyledons of modern aspect, *Baieropsis foliosa*, etc., have never been found as low as the Rappahannock horizon. On the other hand, forms of Sapindopsis, which are so abundant on the Aquia Creek horizon and are so characteristic of it, are wanting. Again, most of the forms, like Populus, etc., so characteristic of the Mount Vernon strata, are equally wanting.

As stated before, most of the rock matrix containing these fossils is a light or grayish chocolate material. This contains the older elements of the flora and may be Mount Vernon in age. But some of the rock material is a light-gray, arenaceous shale, exactly like the Aquia Creek strata at the 72d Milepost. This contains all the younger elements of the flora and may be Aquia Creek in age. The labels accompanying the fossils do not state whether or not all of them come from the same stratum. Professor Ward's collections at the original Mount Vernon locality show

that the Aquia Creek fossils occur in a stratum only a few feet above that carrying Mount Vernon plants. In any case it is not probable that the Hell Hole beds are as old as the Rappahannock strata.

FOSSIL PLANTS FROM CHINKAPIN HOLLOW.

The locality called Chinkapin Hollow is situated between Alexandria and the Episcopal high school known as Fairfax Seminary, being near the latter. It is on the Leesburg pike. The exposures are on a drain worn into the Lower Potomac beds, and just below a spring that discharges into the drain. There are two exposures of fossiliferous strata here. One, which is much the richer in fossils, is a stratum of lignitiferous sand and clay that is, in its top, about on a level with the stream bed. This may be called exposure No. 1. The other is a few yards lower down the stream in a bluff bank made by the cutting down of the stream bed. This may be called exposure No. 2. The plants in the latter are found in thin clay seams of lenticular form, inclosed in the predominant partly indurated sand of the lower Potomac. They lie 10 feet or more above the water level, and hence are above the level of exposure No. 1. The plants in these clays are much more limited in kinds than those in exposure No. 1, while the species are few. The number of individuals of the kinds present is considerable in the case of some. The fossils are reduced to small bits, but these are often remarkably well preserved. They are mostly different species from those of No. 1. The clay of exposure No. 1 has poor cleavage and is very prone to break up into small fragments, so that it is difficult to get good specimens from the exposure as now presented. It is possible that if an excavation were made to reach material not affected by the atmosphere and water better specimens could be found. The bed is so rich in varied forms that it is desirable that it should be explored more fully. As there is a considerable difference in the plants occurring on the two horizons, although they are so near together, they will be distinguished in speaking of the fossils. There is a good deal of difference in the rock material also. The lower exposure, No. 1, is composed of a bed containing layers of poorly indurated sand with much thinner ones of a dark-ash-gray highly plastic clay. The clay layers contain the recognizable fossils. Part of the bed is below the level of the stream. Both the sand and the clay are full of small fragments of plants and bits of lignite,

some of considerable size. The indurated clay of the higher or second exposure, No. 2, is yellowish or buff in color and has an entirely different arrangement, being more sharply distinct from the inclosing sand.

This locality was discovered by Professor Ward on April 16, 1893 (for full details see pp. 382–383), and the principal collection, especially from the lower lignite bed, was made at that time. On July 17 of the same year Professor Ward took me to the place and we made a small collection, chiefly from the upper bed, which was then in a good condition for working out the impressions. The collection made by us from this bed at that time is larger and better than that made at the earlier date. Only four specimens were taken on this occasion from the lower bed, and therefore in the treatment of the flora of that bed it will be assumed that all the specimens belong to the earlier collection except where it is stated that they occur in the later one.

The list of fossils found on the lower horizon, or at exposure No. 1, is as follows:

Angiopteridium strictinerve Font	1 specimen.
Baieropsis adiantifolia Font	1 specimen.
Cladophlebis alata Font	3 specimens.
Cladophlebis Browniana (Dunk.) Sew	1 specimen.
Cladophlebis falcata Font	3 specimens.
Cladophlebis inæquiloba Font	3 specimens.
Cladophlebis parva Font	5 specimens.
Cladophlebis rotundata Font	1 specimen.
Cladophlebis Ungeri (Dunk.) Ward	1 specimen.
Cladophlebis virginiensis Font	2 specimens.
Ctenis imbricata Font	3 specimens.
Ctenopteris angustifolia Font	4 specimens.
Dryopteris fredericksburgensis (Font.) Kn	5 specimens.
Encephalartopsis nervosa Font	1 specimen.
Ficophyllum tenuinerve Font	3 specimens.
Frenelopsis ramosissima Font	7 specimens.
Myrica brookensis Font	2 specimens.
Nageiopsis longifolia Font	4 specimens.
Nageiopsis zamioides Font	4 specimens.
Pecopteris brevipennis Font.?	1 specimen.
Proteæphyllum ovatum Font.?	1 specimen.
Quercophyllum chinkapinense Ward n. sp	14 specimens.
Rogersia angustifolia Font	3 specimens.

Rogersia longifolia Font. ..... 4 specimens.
Scleropteris elliptica Font. ..... 2 specimens.
Sphenolepidium Sternbergianum densifolium Font. ..... 6 specimens.
Sphenopteris latiloba Font.? ..... 2 specimens.
Thyrsopteris bella Font ..... 1 specimen.
Thyrsopteris crassinervis Font ..... 9 specimens.
Thyrsopteris decurrens Font ..... 12 specimens.
Thyrsopteris densifolia Font ..... 4 specimens.
Thyrsopteris divaricata Font ..... 4 specimens.
Thyrsopteris nervosa Font ..... 6 specimens.
Thyrsopteris pinnatifida Font.? ..... 1 specimen.
Zamiopsis insignis Font. ..... 17 specimens.

To obtain this variety of fossils only an imperfect exposure, partly under water, was available. No considerable amount of time was devoted to collecting. No excavation was made and only the outcrop as exposed was examined.

ANGIOPTERIDIUM STRICTINERVE Fontaine.

Pl. CX, Fig. 12.

1889. *Angiopteridium strictinerve* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 116, pl. xxix, figs. 8, 8a, 9.

Only a single specimen of this plant was found on April 16, 1893, consisting of the lower half of a pinnule from which the leaf substance had disappeared, leaving the nervation distinctly impressed upon the clay matrix. This is shown in Pl. CX, Fig. 12.

CLADOPHLEBIS FALCATA Fontaine.

Pl. CXI, Fig. 6.

1889. *Cladophlebis falcata* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 72, pl. iv, figs. 8, 8a; pl. v, figs. 1, 1a, 2–4, 4a, 5, 5a, 6, 6a.

This plant also is rare. The best of the three specimens found is a portion of an ultimate pinna with several well-preserved pinnules of the largest size. It is shown in Pl. CXI, Fig. 6, of this paper.

CLADOPHLEBIS VIRGINIENSIS Fontaine.

Pl. CXI, Fig. 7.

1889. *Cladophlebis virginiensis* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 70, pl. iii, figs. 3, 4, 4a, 5, 5a, 6, 7, 7a, 8, 8a; pl. iv, figs. 1, 1a, 3, 3a, 4, 4a, 4b, 5, 6.

This plant is not common, only 2 specimens occurring. One of these is a fragment of penultimate pinna with a rachis 5 mm. wide. It shows the basal portions of two ultimate pinnæ which carry very large pinnules. These show, toward their tips, a slight dentation, a feature not often seen in the specimens previously found. It is shown on Pl. CXI, Fig. 7, of this paper.

DRYOPTERIS FREDERICKSBURGENSIS (Fontaine) Knowlton.

Pl. CXII, Fig. 2.

1889. *Aspidium fredericksburgense* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 94, pl. xi, figs. 1, 1a, 2, 2a, 2b, 3, 3a, 4, 4a, 5, 6, 6a.
1898. *Dryopteris fredericksburgense* (Font.) Kn.: Bull. U. S. Geol. Surv., No. 152, p. 92.

Five specimens of this species were collected, 4 on April 16, 1893, and 1 doubtful one on July 17. The best specimen is a well-preserved portion of a penultimate pinna with the basal portions of several ultimate pinnæ. These carry many pinnules. It is the form with entire pinnules, and is shown in Pl. CXII, Fig. 2, of this paper.

FRENELOPSIS RAMOSISSIMA Fontaine.

Pl. CXI, Fig. 8.

1899. *Frenelopsis ramosissima* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 215, pls. xcv–xcix; pl. c, figs. 1–3; pl. ci, fig. 1.

This species yields 7 specimens, some of them good. The most complete one is composed of several antepenultimate twigs, carrying a number of penultimate ones. These have a number of ultimate twigs, all pretty well preserved. This is shown in Pl. CXI, Fig. 8. This fossil is highly characteristic of the Fredericksburg or Rappahannock horizon in the Potomac flora, being practically confined to it. It is, then, important as indicating that the Chinkapin Hollow horizon is the same.

MYRICA BROOKENSIS Fontaine

Pl. CVIII, Fig. 8.

1889. *Myrica brookensis* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 310, pl. cl, fig. 11; pl. clvi, figs. 10, 10a.

This species does not seem to have been abundant, as only 2 specimens were obtained. One of these is a fragment of a leaf and the other a nearly entire leaf. This latter is a small leaf with serrate margins. It is given in Pl. CVIII, Fig. 8. It has the nervation of *Myrica brookensis* and is most like the form described in Monograph XV, but the leaf is somewhat wider.

QUERCOPHYLLUM CHINKAPINENSE Ward n. sp.

Pl. CXII, Figs. 3, 4.

Fourteen specimens of what seems to be a new species of Quercophyllum were found at the exposure No. 1. The specific name proposed for this by Professor Ward, *chinkapinense*, is derived from the locality. The best specimens are the two leaves given in Pl. CXII, Figs. 3, 4. Fig. 3 gives a portion of a narrowly elliptical leaf with a very slender midrib. This sends off, very obliquely, slender secondary nerves that curve forward toward the tip of the leaf and nearly reach the margin. The tertiary nerves can not be made out distinctly. They seem to have the indefinite lax nature that is so characteristic of the dicotyledons of the lowest Potomac. This leaf has something of the aspect of a Rogersia, but the secondary nerves are stronger and more definite in their course. Fig. 4 represents an entire leaf well preserved. This has the petiole and all of the leaf except the extreme tip. The end of the leaf is serrate for a short distance with teeth similar to the other species of this genus found in the Lower Potomac. This specimen gives an idea of the shape of the leaf. It is elliptical in form and is narrowed suddenly near the base.

THYRSOPTERIS CRASSINERVIS Fontaine.

Pl. CXII, Figs. 5, 6.

1889. *Thyrsopteris crassinervis* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 130, pl. xli, figs. 1, 1a, 1b, 2, 2a, 2b, 3, 3a, 3b.

This plant shows 9 specimens, and some of them are of larger size than is common in the ferns found at this locality. The best specimen is a con-

siderable part of a penultimate pinna with a number of entire ultimate pinnæ and good pinnules. This is shown in Pl. CXII, Fig. 5. It shows the character of the fern pretty well. Another specimen gives pretty well the termination of an ultimate pinna. It is shown in Fig. 6. This fern, from its firm texture, seems better fitted than most to be preserved.

The following is the list of plants found at the higher exposure, No. 2, at Chinkapin Hollow:

Araucarites aquiensis Font.?	1 specimen.
Athrotaxopsis tenuicaulis Font	12 specimens.
Equisetum Lyellii Mant.?	1 specimen.
Leptostrobus? ovalis Ward nom nov	1 specimen.
Pinus Nordenskiöldi Heer?	2 specimens.
Sphenolepidium Sternbergianum densifolium Font	49 specimens.
Thyrsopteris elliptica Font	1 specimen.
Thyrsopteris rarinervis Font	1 specimen.
Ament of dicotyledon?	1 specimen.

This is a much smaller number of specimens than was found at the locality No. 1. Even this small number would have been diminished if the material containing the fossils had preserved them no better than that of locality No. 1. The indurated clay of locality No. 2 is very fine grained and preserves the plants with unusual perfection, even in the smallest fragments. Indeed, most of the fossils found here are small bits that would not in other material be determinable.

Leptostrobus ? ovalis Ward nom nov.[a]

Pl. CVIII, Figs. 9, 10.

1889. *Leptostrobus* ? (*b*) sp.? Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 231, pl. cxxxvi, figs. 10, 10a.

At the same locality a seed was found that seems to be the same as those described as Leptostrobus ? (*b*) species ? in Monograph XV, p. 231, pl. cxxxvi, fig. 10. The object is composed of a nucleus surrounded by a wing. The wing and nucleus together are nearly round. The nucleus, not very distinctly shown in the specimen figured, is oval in form, 3 mm. long and 2 mm. wide where widest, near one end. As these seeds are

[a] Professor Fontaine contents himself with identifying these seeds with those found by him on the James River and called "Leptostrobus ? (*b*) sp.?" This is an awkward designation, and as it now appears that such seeds occur at other localities it is better to give them a name.—L. F. W.

always detached, it can not be determined with what plant they are connected. This seed is shown natural size in Pl. CVIII, Fig. 9, and enlarged two diameters in Fig. 10. It was collected on April 16, 1893.

SPHENOLEPIDIUM STERNBERGIANUM DENSIFOLIUM Fontaine.

Pl. CIX, Figs. 8, 9.

1889. *Sphenolepidium Sternbergianum densifolium* Font.
1889. Ament of conifer (f) sp.? Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 227, pl. cxxxvi, figs. 8, 8a.

This plant is represented by 49 specimens, being portions of ultimate twigs, seeds, and fragments of aments. The portions of twigs are all very small. They belong to ultimate twigs. The small objects described in Monograph XV, p. 227, pl. cxxxvi, fig. 8, as ament of conifer (*f*) sp.?, exactly resemble a number of fossils found at the second exposure, and they are pretty certainly the same. One of these is shown in the specimen figured in Pl. CIX, Fig. 8, to belong probably to the leafy twig of *S. Sternbergianum densifolium*. The unattached aments are not rare. They are all fragments. One of the most complete of these is about 7 mm. long and not quite 2 mm. wide. The imprints on it indicate that it was probably covered with minute, closely imbricated, chaffy scales. In shape the scales were broadly elliptic and terminated in acute tips. This is shown in Fig. 9. Both the specimens figured were collected on April 16, 1893. It is to be noted that such objects are abundant at the 72d Milepost, where the leafy twigs of *S. Sternbergianum densifolium* are common.

Ament of a DICOTYLEDON ? Fontaine.

Pl. CVII, Fig. 11.

A single specimen showing a fragment of what seems to be the ament of some dicotyledon was found at locality No. 2. It is nearly entire. It is cylindrical in form, and from the imprint left seems to have been covered with elliptical scales that were rather thick in texture and imbricated. Pl. CVII, Fig. 11, shows it. It was collected on April 16, 1893.

The horizon of all the plants from Chinkapin Hollow is clearly that of the Rappahannock series. There is no difference in age between those from the two localities except the time required to deposit the intermediate 20 feet of homogeneous materials.

LOCALITIES IN THE DISTRICT OF COLUMBIA.

FOSSIL PLANTS FROM SIXTEENTH STREET.

[Pl. LXXX, No. 122.]

The fossil plants next to be noticed come from Washington, D. C., in an excavation made on Sixteenth street (see pp. 382–383 and Fig. 10, on p. 387). They occur on the east side of the cut, 6 feet above its base. The material belongs to the basal strata of the Lower Potomac, probably somewhat higher than the fossils from near Lorton. The locality is not favorable for collecting good specimens, as the plants are contained in lumps of clay which seem to have been torn up and transported. Hence it is probable that their original position was at a somewhat lower horizon.

Determinable plants were collected by Professor Ward and Mr. Victor Mason on May 7, 1893, and by Professor Ward and myself on July 14, 1893. They all occurred in the Rappahannock clays, No. 2 of the section on p. 386, overlying the cross-bedded sands. The following species were found:

Athrotaxopsis tenuicaulis Font.	11 specimens.
Nageiopsis angustifolia Font.	1 specimen.
Podozamites distantinervis Font.?	2 specimens.
Thyrsopteris angustifolia Font.	2 specimens.

FOSSIL PLANTS FROM THE NEW RESERVOIR.

[Pl. LXXX, No. 121.]

The locality designated "new reservoir" is situated in the city of Washington. The excavation made for this reservoir reached and cut into the basal beds of the Lower Potomac. The plants in the collection come from two spots near the base. One is on the east side, nearly opposite the shaft, and above the lignite bed at the bottom of the reservoir. The other is on the west side near the shaft, 6 feet above the bottom of the reservoir. These are practically on the same horizon, which is about the same as that of those from Cockpit Point and Lorton.

The two localities were discovered by Professor Ward on September 18, 1892.[a] The one on the east side near the bottom of the reservoir yielded most of the plants. Nearly all the specimens collected at that

[a] The exact positions of both localities are described in the historical part of this paper (see pp. 379–380).—L. F. W.

locality on the day named belong to the fern *Thyrsopteris rarinervis*, but some tubers of *Equisetum marylandicum* and some other Thyrsopteris forms also occur. The plants from the locality on the west side are all different from these, no ferns having been found there, but a cone probably of *Sphenolepidium virginicum*, a leaf of *Dioonites Buchianus?*, and one of *Baieropsis longifolia* were found.

On October 2, 1892, Professor Ward and Doctor Hollick collected at the first-named locality a number of specimens, but nearly all of them belong to *Equisetum marylandicum*.

On July 7, 1893, I went to this same place with Professor Ward and we secured a few specimens, but they were mostly different from any previously collected, including a species of Brachyphyllum. This shows that the different clay seams hold different plants, and that the flora of these beds is very rich and varied.

The following species occur in all these collections:

Baieropsis longifolia Font.	1 specimen.
Brachyphyllum parceramosum Font.?	3 specimens.
Cladophlebis Browniana (Dunk.) Sew.	1 specimen.
Dioonites Buchianus (Ett.) Born.?	1 specimen.
Equisetum marylandicum Font.	19 specimens.
Onychiopsis psilotoides (Stokes & Webb) Ward	1 specimen.
Sphenolepidium virginicum Font.?	1 specimen.
Thyrsopteris densifolia Font.	1 specimen.
Thyrsopteris divaricata Font.?	2 specimens.
Thyrsopteris elliptica Font.	3 specimens.
Thyrsopteris nervosa Font.	3 specimens.
Thyrsopteris rarinervis Font.	60 specimens.
Zamiopsis insignis Font.?	1 specimen.

Most of the specimens from the new reservoir seem to have been reduced to small fragments, but in many cases they are pretty well preserved, for the leaf substance is often retained

EQUISETUM MARYLANDICUM Fontaine.

Pl. CIX, Fig. 10.

1889. *Equisetum marylandicum* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 65, pl. ii, figs. 10, 10a.

This species stands second in abundance at this locality, and a good many specimens were obtained. It is a peculiar fact that nearly all of

them are rhizomes, many with tubercles attached. These are globular in form, proportionally large in size, and they seem to grow in pairs, one on each side of the rhizome, opposite to each other. Pl. CIX, Fig. 10, shows one of these rhizomes. Most of the specimens were collected on October 2, 1892, and all at the locality on the east side. The one figured was collected on July 7, 1893.

ONYCHIOPSIS PSILOTOIDES (Stokes & Webb) Ward.[a]

Pl. CXIII, Fig. 1.

The only specimen of this plant that was found, a rather poor one, has been drawn to form Fig. 1 of Pl. CXIII. It is a portion, 6 cm. long, of a penultimate pinna with a number of parts of ultimate pinnæ attached to it, and some detached, all carrying fragments of pinnules. Some of these show distinctly the characteristic narrow acute lobes and teeth of the species. It is similar to the form figured in Monograph XV, pl. 1, fig. 2. It was collected by Professor Ward and Doctor Hollick on October 2, 1892.

THYRSOPTERIS RARINERVIS Fontaine.[b]

Pl. CXIII, Figs. 2, 3.

As above stated, *Thyrsopteris rarinervis* is the most abundant fossil found here. No fewer than 60 specimens were obtained, and many more might have been secured had it been desirable. Some of them are pretty well preserved. One of these is drawn to form Pl. CXIII, Fig. 2. It shows considerable portions of several penultimate pinnæ with good ultimate ones, carrying well-preserved pinnules. Most of the specimens, however, are fragments of ultimate pinnæ.

This fern seems to have had very long, slender stipes, which sometimes are shown without any foliage, and then seems to be a fossil quite different from that in which the foliage is shown. Pl. CXIII, Fig. 3, shows an extreme case of this kind. The specimens all come from the locality on the east side of the reservoir. One was obtained on October 2, 1892, and one on July 7, 1893. The rest, including the ones figured, occur in the original collection made on September 18, 1892.

[a] For the synonymy of this species see p. 155.
[b] For the synonymy of this species see p. 225.

FOSSIL PLANTS FROM TERRA COTTA.

[Pl. LXXX, No. 120.]

At Terra Cotta station, on the Metropolitan Branch of the Baltimore and Ohio Railroad, near Washington, above the bridge over the railroad, in disturbed clay over the basal Potomac sand, I collected on July 23, 1893, an obscure plant impression that looks like the rhizome of some Equisetum. It is probably *E. virginicum* Font.

FOSSIL PLANTS FROM IVY CITY.

[Pl. LXXX, No. 130.]

On July 21, 1896, Mr. Arthur Bibbins made a small collection of fossil plants from this locality, and two days later he and Professor Ward obtained a few additional specimens from the same place. Both collections are deposited in the National Museum. The locality is a sandpit near an iron mine, adjacent to the northwest corner of the Ivy City race course. The plants occur in ferruginous crusts at the base of the pit. They are found in a coarse sand cemented by iron oxide into a sandstone, hence the preservation is very imperfect, on account both of the comminuted condition of the plants and of the action of the iron on them. The following species were found there:

Cladophlebis sphenopteroides Font.?	1 specimen.
Pecopteris constricta Font	1 specimen.
Sphenolepidium Kurrianum (Dunk.) Heer?	1 specimen.
Thyrsopteris Meekiana Font.?	1 specimen.
Thyrsopteris nervosa Font	5 specimens.
Thyrsopteris rarinervis Font.?	5 specimens.

Most of these fossils are too imperfect to permit a positive identification. They are in the form of small bits that are generally macerated by water action. This collection is not sufficient to prove the age of the strata, but it strongly indicates that they belong to the horizon of the Rappahannock or Fredericksburg beds.

FOSSIL PLANTS FROM LANGDON.

[Pl. LXXX, No. 131.]

This locality was discovered by Mr. Arthur Bibbins, who, on June 10, 1896, made a considerable collection from it for the State Geological Survey of Maryland.

A second collection for the same survey was made, as Mr. Bibbins states, from this locality, but the labels do not give any locality or date. They simply bear the mark: "M. G. S." and the numbers 5913–5964.[a]

The third collection was made by Professor Ward on May 11, and the fourth, also by him, on May 17, 1897. These are both large collections.

A fifth but smaller collection was made by Professor Ward and Dr. Arthur Hollick on June 14, 1897. This last was taken entirely from one impure iron-ore nodule.

The exact locality is in the large cut of the Baltimore and Ohio Railroad between Langdon and Rives stations, but nearer the former and chiefly toward the Langdon end of the cut. Langdon is the present name of the station formerly called Mills station, being the place where Clark Mills, the sculptor, resided and where his foundry was located. It was here that the Statue of Liberty designed by Crawford was cast by Clark Mills. The plants occur in true white iron ore or carbonate of iron, but the slabs holding the vegetable matter consist of impure iron ore and have a somewhat reddish color. Nearly or quite all the specimens came from the southeast side of the tracks, and the bed has a length of over 100 yards and a thickness of about 6 feet. The best specimens were obtained about 6 feet above the tracks, but some from as high as 10 feet. These latter occurred nearer the middle of the cut, viz, 200 yards beyond the whistle post for Langdon.

From all these collections the following species were obtained. The number of specimens is for all collections, and the date of collection and the proprietorship are stated only for the figured types and for cases in which only one specimen was secured:

Athrotaxopsis expansa Font.	52 specimens.
Athrotaxopsis tenuicaulis Font.	15 specimens.
Ctenopteris insignis Font.?	2 specimens.
Cycadeospermum ellipticum Font.	2 specimens.
Cycadeospermum obovatum Font.	1 specimen.
Ficophyllum tenuinerve Font.?	1 specimen.
Glyptostrobus (Taxodium) brookensis (Font.) Ward	37 specimens.
Nageiopsis heterophylla Font.?	1 specimens.

[a] This may be the collection made by Mr. Bibbins and myself on July 28, 1896, when he first guided me to the locality, but it is scarcely large enough, as we had difficulty in carrying the specimens to the railroad station. They were left there until Mr. Bibbins had them shipped to Baltimore.—L. F. W.

Nageiopsis zamioides Font. ..... 2 specimens.
Platypterygium densinerve Font.? ..... 1 specimen.
Quercophyllum tenuinerve Font.? ..... 1 specimen.
Rogersia angustifolia Font.? ..... 5 specimens.
Rogersia angustifolia parva Font. n. var. ..... 5 specimens.
Rogersia longifolia Font. ..... 4 specimens.
Saliciphyllum ellipticum Font. ..... 2 specimens.
Sphenolepidium Sternbergianum densifolium Font. ..... 60 specimens.
Thyrsopteris decurrens Font. ..... 1 specimen.
Thyrsopteris divaricata Font.? ..... 5 specimens.
Thyrsopteris insignis Font. ..... 15 specimens.
Thyrsopteris nervosa Font ..... 19 specimens.
Thyrsopteris rarinervis Font. ..... 70 specimens.
Zamiopsis insignis Font ..... 2 specimens.

Ctenopteris insignis Fontaine?

Pl. CXII, Fig. 7.

1889. *Ctenopteris insignis* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 156, pl. lxi, figs. 4, 4a, 5; pl. lxii, figs. 1, 1a; pl. lxiii, figs. 1, 2.

Two specimens were found of a plant that agrees well with *C. insignis*, a form that is highly characteristic of the strata of the Lower Potomac of Virginia, on the horizon of the Fredericksburg beds. Although the agreement is close, I hesitate to determine this plant positively as *C. insignis*, for the amount of material is too small. Pl. CXII, Fig. 7, represents one of these specimens, and it is the terminal portion of an ultimate pinna with several pinnules. It occurs in the collection made by Professor Ward on May 11 and 17, 1897, the specimens found at the two dates not being distinguished.

Platypterygium densinerve Fontaine?

Pl. CXII, Fig. 8.

1889. *Platypterigium densinerve* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 169, pl. xxx, fig. 8; pl. xxxi, figs. 1, 4; pl. xxxii; pl. xxxiii, figs.1, 1a; pl. xxxiv, fig. 1; pl. xxxv, figs. 1, 2.

A fragment of a large leaf was found at Langdon which is a species of Platypterygium. It is shown in Pl. CXII, Fig. 8. It contains a portion of one side of the midrib, 4 cm. long. The greater part of the width of the midrib is missing, so that its true size is not shown. To

the side that is preserved there is attached a part of the lamina of the leaf that indicates a width for the lamina on that side of at least 5 cm. This portion of the lamina is distorted in the upper portions, it being bent forward. The width may have been greater than 5 cm. This indicates for the entire leaf a width of at least more than 10 cm. The portion of the lamina preserved is not segmented. The nerves are parallel, closely placed, and single. They go off from the midrib at a large angle and are slightly curved forward.

The plant agrees closely with *Platypterygium densinerve* Font., a plant highly characteristic of the Fredericksburg locality in the Rappahannock group of the Lower Potomac. This is described in Monograph XV, pp. 169–170. The Fredericksburg plant is very irregularly segmented and the wider segments in it are broader than the portion shown in the Langdon specimen. The latter may be compared with fig. 1 of pl. xxii of the work quoted. The small amount of material does not permit a positive identification with *P. densinerve*.[a]

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[a] One of the specimens that I collected in May, 1897, originally showed a narrow strip, about 2 cm. wide at one end and only 3 mm. wide at the other, with a length of 5 cm., across which fine nerves could be seen to run, indicating a cycadaceous leaf. This was returned by Professor Fontaine with the following words on the label: "Fragment of a large cycad leaf not determinable." In the manuscript of his report this specimen was described as follows:

"Undetermined large cycad. A fragment of the leaflet of a cycadaceous plant was found which indicates a leaf of considerable size, larger than that of a Zamites, from which it differs in other respects than size. Not enough of the plant was obtained to show anything definite, as the specimen is a small fragment of a leaflet."

On a casual examination of the specimen I perceived that the fine nerves ran under the adjacent rock substance, and a few taps with a hammer caused the rock to cleave on the plane of the leaf and brought out the amount of surface that is seen in the figure with 4 cm. of attachment to the midnerve, which is on the side opposite to that originally exposed and was not visible in the specimen as first examined by Professor Fontaine.

I therefore returned it to him on March 12, 1903, and in the letter accompanying it I said:

"I am sending you in a small box by mail a specimen from the Langdon locality, on which you recognized a small portion of a large cycad leaf, and so labeled it. I have worked out all that existed in the specimen and it is quite distinctive. It seems to be entirely different from anything else in the Potomac formation. You can see the large midrib to which a wide blade is attached on one side, and you can follow the fine nerves, passing entirely across the specimen, with a somewhat upward curve. So far as I can see, there is no areolation or anastomosis. It seems somewhat like a Nilsonia of the nonsegmented group."

He returned the specimen the next day with the description and identification given above.

There should properly be no genus Platypterygium. Schimper, in Zittel's Handbuch, p. 225, which was in the second fascicle, dated 1880, in treating the genus Anomozamites, created a subgenus Platypterygium for certain very large-leaved forms, the chief of which are the *Pterophyllum Braunsii* Schenk, *P. princeps* Oldh. & Morr., *P. Medlicottianum* Oldh. & Morr., and *P. Morrisianum* Oldh., all of which he had already referred to Anomozamites in his Traité de Paléontologie Végétale, Vol. II, pp. 142–143, 1870, without placing them in any subgenus. Feistmantel, in his Fossil Flora of some of the Coal Fields of Western Bengal (Foss. Fl. Gond. Syst., Vol. IV, Pt. II), p. 37, accepted Schimper's subgenus Platypterygium, calling it such, and referring to it his *Anomozamites* (*Pterophyllum*) *Balli*, but treating it as *Platypterygium Balli*, thereby virtually raising Platypterygium to generic rank. Professor Fontaine, in his Potomac Flora (see synonymy above),

ROGERSIA ANGUSTIFOLIA PARVA Fontaine n. var.

Pl. CXI, Fig. 9.

At this locality five specimens of a dicotyledon were found that indicate a smaller and narrower leaf than the normal *Rogersia angustifolia*. In fact, the leaves are so narrow that they suggest *Cephalotaxopsis magnifolia*.[a] The nervation, however, although vaguely shown, is that of a dicotyledon, and the leaf substance is thinner than that of a Cephalotaxopsis. This may be a new genus, but the amount of material is too small and the preservation too imperfect to permit the establishment of its full character. It may provisionally be regarded as a variety of *Rogersia angustifolia*, which it resembles in all determinable points except size. The specimen figured was collected by Professor Ward in May, 1897.

ROGERSIA LONGIFOLIA Fontaine.

Pl. CXII, Fig. 9.

1889. *Rogersia longifolia* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 287, pl. cxxxix, fig. 6; pl. cxliv, figs. 2, 2a, 2b; pl. cl, fig. 1; pl. clix, figs. 1, 2.

This is a plant which in the Virginia Lower Potomac is confined to the Rappahannock horizon and appears to be represented by 4 fragments of leaves. Some of them are so poorly preserved as to be

followed Feistmantel's method and described two species of Platypterygium (misspelling the name *Platypterigium*), *P. densinerve* and *P. Rogersianum*, to the former of which he doubtfully refers the specimen now under consideration.

As all the other forms that had prior to that date (1889), or have ever, been referred to the subgenus Platypterygium come from much older strata (Rhetic or at latest Jurassic), the placing of these Lower Cretaceous forms in that category must be prima facie questionable. It is of interest to note that Mr. Seward, who examined the specimens in the United States National Museum in 1897, makes, in his Jurassic Flora of Yorkshire, p. 224, 1900, the following remark:

"Attention may be drawn to the large leaves figured by Fontaine from the Potomac plant beds under the name *Platypterigium densinerve*. An examination of a few specimens of this species in the Washington Geological Museum led me to regard the plant as probably a Nilssonia."

It is true that Nilsonia is also a chiefly Jurassic genus, but undoubted forms of it occur in the Lower Cretaceous even of America (see pp. 252, 253, 254, 271, 284). The conjecture expressed in my letter to Professor Fontaine when I sent him this specimen may therefore still prove not to have been so very wide of the mark. At any rate, such forms are calculated to furnish crumbs of comfort to those who regard the Potomac formation as Jurassic.—L. F. W.

[a] Monograph XV, pp. 236, 237.

doubtful. Pl. CXII, Fig. 9, gives the best specimen. This was collected by Mr. Bibbins for the Maryland Geological Survey on June 10, 1896.

SALICIPHYLLUM ELLIPTICUM Fontaine.

Pl. CXI, Fig. 10.

1889. *Saliciphyllum ellipticum* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 303, pl. cxlvi, figs. 2, 4; pl. cl, fig. 8; pl. clxiii, fig. 5; pl. clxvi, fig. 2.

This seems to have been one of the rarer plants in the Langdon strata. In the considerable number of specimens collected by Professor Ward and Mr. Bibbins only two are referable to this species. One of these specimens is nearly the whole of the upper part of a leaf, as given in Pl. CXI, Fig. 10. The margins are not well preserved. These leaves are not so well preserved as some of those figured in Monograph XV, but the finer nervation is a little better shown. Both the specimens were collected by Mr. Bibbins for the Maryland State Geological Survey on June 10, 1896.

SPHENOLEPIDIUM STERNBERGIANUM DENSIFOLIUM Fontaine.[a]

Pl. CXII, Figs. 10, 11.

Sixty specimens of this conifer, with short acicular leaves, were found in the collections. Most of them are poorly preserved and obscure, but some are distinct enough to be identified without doubt. This species occurs on all the horizons of the Lower Potomac of Virginia, but it is most common on the upper one, or that of the Aquia Creek strata. Some of the specimens show very delicate leaves whose full character can be made out only with the help of a lens. Although smaller even than the most slender of the Virginia forms, they do not otherwise seem different, and hence can hardly be made a new variety. Pl. CXII, Fig. 10, represents one of the stoutest forms, being a fragment of an ultimate twig. This was collected by Professor Ward in May, 1897. Fig. 11 depicts one of the small delicate kind showing portions of several ultimate twigs. This was obtained from the nodule of iron ore broken up by Professor Ward and Dr. Hollick on July 14, 1897.

[a] See pp 507, 524.

THYRSOPTERIS DECURRENS Fontaine.

Pl. CXI, Fig. 11.

1889. *Thyrsopteris decurrens* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 130, pl. xliii, figs. 7, 7a; pl. xlvi, figs. 2, 2a, 4; pl. xlix, figs. 5, 5a, 6, 6a, 7.

Only one specimen of this fern was found at the Langdon locality. It occurs in the collection made by Professor Ward in May, 1897. It consists of the upper part of a compound pinna and may be compared with the specimen represented by fig. 7 of pl. xlix of Monograph XV. It is shown on Pl. CXI, Fig. 11. This species has a wide range in the Virginia Potomac.

ZAMIOPSIS INSIGNIS Fontaine.

Pl. CXIII, Figs. 4, 5.

1889. *Zamiopsis insignis* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 162, pl. lxii, fig. 3; pl. lxiv, figs. 1, 3; pl. lxv, figs. 4–6; pl. lxvi, fig. 2; pl. lxvii, fig. 7.

Two impressions of a plant were found that belong to *Zamiopsis insignis*. This remarkable plant is highly characteristic of the lowest strata of the Lower Potomac of Virginia. At the time of the preparation of Monograph XV it had been found only at the Fredericksburg locality, but since that time it has been discovered in abundance near Alexandria, in the basal beds at Chinkapin Hollow. This is a type that is easily detected even in small fragments. The specimens show portions of ultimate pinnæ. The form given in Pl. CXIII, Fig. 4, comes from lower down on the plant, where the pinnules are larger. Several of these are shown. The form given in fig. 5 is the terminal portion of an ultimate pinna, where the pinnules are narrow and show only the characteristic toothing of the plant. The distribution of this species is geologically so well defined that the plant is especially valuable to fix the horizon of the strata in which it occurs.

Both the specimens were found by Professor Ward in May, 1897.

GENERAL REMARKS.

The account of the plants given above makes it evident that the locality yielding them is on the horizon of the basal beds of the Potomac

of Virginia, and not that of the Brooke or Aquia Creek strata. A brief résumé may make this plainer. For the sake of reference in this account I will refer to the basal part as the Rappahannock beds. The following plants, being doubtfully determined, will not have so much weight in determining age:

Ctenopteris insignis?
Ficophyllum tenuinerve?
Nageiopsis heterophylla?
Platypterygium densinerve?
Quercophyllum tenuinerve?
Rogersia angustifolia?
Thyrsopteris divaricata?

All of these are confined to the horizon of the Rappahannock beds.

We may also omit the new variety, *Rogersia angustifolia parva*, as it does not occur in the Virginia beds.

This leaves, as having considerable value in determining the age of the Langdon beds, the following species:

Athrotaxopsis expansa.
Athrotaxopsis tenuicaulis.
Cycadeospermum ellipticum.
Cycadeospermum obovatum.
Glyptostrobus (Taxodium) brookensis.
Nageiopsis zamioides.
Rogersia longifolia.
Saliciphyllum ellipticum.
Sphenolepidium Sternbergianum densifolium.
Thyrsopteris decurrens.
Thyrsopteris insignis.
Thyrsopteris nervosa.
Thyrsopteris rarinervis.
Zamiopsis insignis.

The two species of Athrotaxopsis and the two of Cycadeospermum, *Nageiopsis zamioides*, *Thyrsopteris insignis*, and *T. nervosa* are all confined to the Rappahannock horizon. *Rogersia longifolia*, *Saliciphyllum ellipticum*, *Sphenolepidium Sternbergianum densifolium*, *Thyrsopteris decurrens*, and *T. rarinervis*, though found in the lower beds, occur also on the Aquia Creek horizon. *Glyptostrobus* (*Taxiodium*) *brookensis* is the only plant confined to the horizon of the Aquia Creek beds in Virginia.

The absence of all dicotyledons of the more modern aspect and the presence of only a very few of the archaic type, characteristic of the basal beds, is strong proof that the strata are older than the Aquia Creek beds. It is safe to affirm that the latter will, in all cases, contain a large element of dicotyledons of comparatively modern aspect.

FOSSIL PLANTS FROM THE QUEENS CHAPEL ROAD.

[Pl. LXXX, near No. 131.]

On May 11, 1897, Professor Ward collected, in a cutting for the electric railroad which begins a few steps beyond the crossing of the Queens Chapel road and extends northeastward for a distance of several hundred yards, a specimen in counterparts of a small leafy twig belonging to *Sphenolepidium Sternbergianum densifolium*. It occurs in typical iron-ore rock of a dark-reddish color, differing scarcely at all from that yielding the fossil plants at the Langdon locality, which is only a short distance from there. The age is evidently the same.

LOCALITIES IN MARYLAND.

FOSSIL PLANTS FROM ROSIERS BLUFF, FORT FOOTE, MARYLAND.

[Pl. LXXX, No. 143.]

Rosiers Bluff forms the bank of the Potomac River above Fort Foote. The fossils are found 200 yards below Notley Hall wharf, and about 30 feet above the water, on the Fort Foote reservation (see pp. 373–375). The plant-bearing stratum is 4 or 5 feet thick and is composed of partly indurated sand interstratified with layers of clay. The material is lithologically similar to that which yields the fossils at the 72d Milepost in Virginia. The fossils occur in a similar manner and are in the main the same species as those of the Virginia locality, so that there can be no doubt that the horizon is that of the Aquia Creek series. The better specimens occur in the clay. This is sandy and has poor cleavage. It tends to break up into lumps, so that the plants can rarely be obtained in specimens as large as they are contained in the clay. They seem, however, to have been in many cases much comminuted before entombment. The locality was discovered by Professor Ward on June 13, 1891, but the principal collection was made by him and Mr. David White on November 25, 1891. As these collections were both made at the same place, no attempt will be made to distinguish the specimens obtained at the two dates except in the case of the figured types. The specimens of Sapindopsis are the largest that are found

here and the clay is full of small fragments of the plants of this genus. The following is the list of plants found at Rosiers Bluff:

Abietites angusticarpus Font	1 specimen.
Araucarites aquiensis Font	10 specimens.
Aristolochiæphyllum crassinerve Font	2 specimens.
Baieropsis adiantifolia Font.?	1 specimen.
Baieropsis foliosa Font	5 specimens.
Brachyphyllum crassicaule Font	4 specimens.
Celastrophyllum acutidens Font	31 specimens.
Cladophlebis constricta Font.?	1 specimen.
Cladophlebis parva Font	1 specimen.
Cycadeospermum obovatum Font	4 specimens.
Eucalyptus rosieriana Ward n. sp	3 specimens.
Ficus myricoides Hollick	3 specimens.
Leptostrobus longifolius Font	2 specimens.
Menispermites virginiensis Font.?	2 specimens.
Nageiopsis angustifolia Font	6 specimens.
Nageiopsis longifolia Font	8 specimens.
Nageiopsis zamioides Font	5 specimens.
Onychiopsis psilotoides (Stokes & Webb) Ward	2 specimens.
Pinus schista Ward n. sp	5 specimens.
Podozamites pedicellatus Font	1 specimen.
Populophyllum minutum Ward	1 specimen.
Sapindopsis brevifolia Font	3 specimens.
Sapindopsis elliptica Font	1 specimen.
Sapindopsis magnifolia Font	22 specimens.
Sapindopsis tenuinervis Font	32 specimens.
Sapindopsis variabilis Font	92 specimens.
Sequoia cycadopsis Font	1 specimen.
Sphenolepidium dentifolium Font	6 specimens.
Sphenolepidium Sternbergianum densifolium Font	9 specimens.
Thinnfeldia variabilis Font	1 specimen.
Thyrsopteris crassinervis Font.?	1 specimen.
Thyrsopteris elliptica Font	1 specimen.
Thyrsopteris nervosa Font	2 specimens.
Thyrsopteris rarinervis Font	6 specimens.
Zamites tenuinervis Font	4 specimens.

BRACHYPHYLLUM CRASSICAULE Fontaine.

Pl. CXIII, Fig. 6.

1889. *Brachyphyllum crassicaule* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 221, pl. c, fig. 4; pl. cix, figs. 1, 1a, 1b, 2–4, 4a, 5–7; pl. cx, figs. 1–3, 3a; pl. cxi, figs. 6, 7, 7a; pl. cxii, figs. 6–8; pl. clxviii, fig. 9.

Four specimens of *B. crassicaule* were found at this locality. The best specimen is a distinctly defined terminal portion of a penultimate twig, showing a number of entire ultimate branches. It is shown on Pl. CXIII, Fig. 6. It was collected on November 25, 1891.

CELASTROPHYLLUM ACUTIDENS Fontaine.

Pl. CXIII, Figs. 7, 8.

1889. *Celastrophyllum acutidens* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 305, pl. clvi, figs. 8, 8a.
1889. *Celastrophyllum obtusidens* Font.: Ibid., p. 305, pl. clvi, fig. 5.

At the 72d Milepost in Virginia 31 specimens were found of a dicotyledon that seems to be the same with *C. acutidens* of the Aquia Creek horizon. Nearly all the specimens are fragments of leaves that show only one margin entire. The part thus presented entire, however, varies in the different cases, so that an idea of the whole leaf may be obtained. One specimen is a nearly entire leaf. Two species of Celastrophyllum were described in Monograph XV, from the locality at the 72d Milepost,[a] as *C. obtusidens* and *C. acutidens*, distinguished by the greater or less acuteness of their marginal teeth. It was suggested that they might be varieties of the same species, but the amount of material then available was not sufficient to indicate the existence of transitional forms.

The specimens from Rosiers Bluff show gradation from the forms with acute teeth to those with obtuse ones, indicating that all are variations of one species. The leaves with more acute teeth seem to be the normal ones, hence the specific name retained should be *acutidens*.

As the specimens from Rosiers Bluff are numerous, they show more of the character of the leaf than could be made out from the few forms obtained at the 72d Milepost. The toothing is more often subacute

[a] Op. cit., p. 305, pl. clvi, figs. 5, 8.

to acute than obtuse. The average leaves resemble most that one given in the Potomac Flora, pl. clvi, fig. 5, but some of them seem to have been longer. They seem to have been oblong in form, with a rather strong midnerve. The secondary nervation is slender, going off pinnately and very obliquely from the midrib and curving toward the apex of the leaf with a flexuous course. The secondary nerves send off at a very large angle tertiary ones, which anastomose with their like, forming irregular, large polygonal meshes. This tertiary nervation is, in proportion to the secondary, very strong. Pl. CXIII, Fig. 7, gives a fragment of a leaf of the largest size with the teeth somewhat blunted by maceration. Fig. 8 depicts a smaller, nearly entire, leaf. The toothing in this latter is closer and less deeply cut than in many of the specimens. In general the teeth of this plant vary a good deal in size, depth, and sharpness. Both the specimens figured were collected on November 25, 1891.

EUCALYPTUS ROSIERIANA Ward n. sp.[a]

Pl. CXIII, Figs. 9, 10.

Three specimens of a dicotyledon from Rosiers Bluff were indicated on the labels by Professor Ward as *Eucalyptus Geinitzi* Heer. As this species is unknown to me I have requested Professor Ward to describe it (see accompanying footnote).

[a] Three specimens of a dicotyledonous leaf with the form and nervation of Eucalyptus were collected by Mr. White and myself on November 25, 1891, which upon examination I was inclined to refer to *E. Geinitzi* Heer, and had so labeled them. Professor Fontaine returned them without description with the request that I treat them, as he was unacquainted with that species. He indicated one of the specimens to be figured, and I have thought best to figure two of them, to bring out the characters. On further comparison with all the figures that have been published of *E. Geinitzi*, both in Europe and in America, I have decided that the form from Rosiers Bluff does not belong to that species, but is a new species, and I name it for the locality. It has the following character:

Leaves small and narrow, about 7 cm. long by 15 mm. wide, widest at about the middle, tapering to both base and summit, somewhat falcate, especially in the upper part; margins entire, but somewhat undulate; midrib strong, central through the leaf; lateral nerves distinct, numerous, close together, parallel, proceeding from the midrib at a large angle so as to be only slightly ascending, curving upward near the margin and forking at the point where the curvature is greatest, the lower branch abruptly descending and joining the next nerve below in such a manner as to produce an apparent marginal nerve 1 mm. from the margin, numerous nervilles crossing the spaces between the secondaries at various angles, forming a network of very irregular meshes; petiole, base, and tip unknown.

This species is nearest to *Eucalyptus ? angustifolia* Newb.: Flora of the Amboy Clays (Monogr. U. S. Geol. Surv., Vol. XXVI), p. 111, pl. xxxii, figs. 1, 6, 7, especially as seen in fig. 7, but the secondary nerves are much more nearly horizontal and the form and nervation are different.—L. F. W.

FICUS MYRICOIDES Hollick.[a]

Pl. CXII, Fig. 12.

1895. *Ficus myricoides* Hollick in Newberry: Flora of the Amboy Clays (Monogr. U. S. Geol. Surv., Vol. XXVI), p. 71, pl. xxxii, fig. 18; pl. xli, figs. 8, 9.

Three specimens of a dicotyledon were obtained from the Rosiers Bluff locality, one on June 13 and two (including the one figured) on November 25, 1891, that are indicated by Professor Ward on the labels as *F. myricoides* Hollick. As this species is unknown to me I have requested Professor Ward to describe it (see footnote).

PINUS. SCHISTA Ward n. sp.

Pl. CXII, Figs. 13–15.

Five small winged seeds were obtained at Rosiers Bluff that seem to belong to a new species of Pinus. The seeds proper are elliptical in form, and average a little more than 2 mm. in length and $1\frac{1}{2}$ mm. in width in the widest part. The wing is, in proportion to the seed, very large and projects beyond it at one end. In the largest the length of the wing is nearly 1 cm. The wing is split into two segments. On most of the seeds obtained only one of the segments was retained, but its shape shows that it forms one of an opposing pair. In a few cases both segments were preserved.[b] The seeds are not unlike those of *Picea excelsa* (Poir.) Link.

Pl. CXII, Fig. 14, gives a seed of normal size and shape, with one segment of a wing. Fig. 15 shows one with the wing retaining portions of both segments. Both the specimens figured were collected on November 25, 1891.

At Rosiers Bluff a few fragments of one-nerved, Pinus-like leaves were found. These may belong to this species, but they are too vague and imperfect to show any particular character.

[a] A more thorough comparison, aided by a good figure, does not change my opinion that these specimens belong to *F. myricoides*, but it is true that I have not yet seen Doctor Hollick's types.—L. F. W.

[b] Miss Mary Mason Mitchell, who made the drawings, observed that at least in one case (see Fig. 14) nerves or fibers crossed from one part to the other of the split wing, tending to prove that the splitting is accidental. I had suspected this, and noted the further tendency of the ends of the wings to split or fray and become ragged. Nevertheless, all the seeds in the collection are thus divided into two divaricate halves, which I have never observed in any other seed of Pinus, living or fossil.—L. F. W.

PODOZAMITES PEDICELLATUS Fontaine.

Pl. CXIV, Fig. 1.

1889. *Podozamites pedicellatus* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 180, pl. lxxvi, fig. 1; pl. lxxviii, fig. 7; pl. lxxxii, fig. 5.

The single specimen of this plant collected by Professor Ward on June 13, 1891, is well characterized. It is the lower part of a detached leaflet that is well preserved and shows a considerable portion of the pedicel that attaches the leaflets of this plant. It is shown in Pl. CXIV, Fig. 1.

POPULOPHYLLUM MINUTUM Ward.[a]

Pl. CVIII, Fig. 11.

SAPINDOPSIS VARIABILIS Fontaine.

Pl. CXIV, Fig. 2.

1889. *Sapindopsis variabilis* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 298, pl. cli, figs. 1, 1a; pl. clii, figs. 1, 4, 4a; pl. cliii, fig. 3; pl. cliv, figs. 2–4, 4a; pl. clv, figs. 2–5.

This is the most common and best-preserved fossil found at Rosiers Bluff, 92 specimens occurring in the collections. Most of the specimens, however, are fragments of leaves. No doubt if excavations had been made and time devoted to the search for fossils a greater variety as well as more and better specimens might have been secured, not only of the Sapindopsis forms, but of others.

The terminal leaflets of Sapindopsis show a decided tendency to union at their bases. This is especially true of the uppermost three. One specimen of *S. variabilis* obtained on November 25, 1891, shows a marked departure from this rule. This is composed of the basal parts and most of the last three leaflets. They are not attached to a stem, but stand in their natural position, indicating a former attachment. These leaflets are not confluent at their bases, as shown in Pl. CXIV, Fig. 2.

[a] See p. 499. One specimen from Rosiers Bluff has an impression of a small dicotyledonous leaf which Professor Fontaine labeled *Populus potomacensis* without any mark denoting doubt. He did not, however, include that species in the plants enumerated in his manuscript as found at that locality. Although a smaller leaf still than that from the Mount Vernon beds, the form and nervation are substantially the same, and there seems no doubt that this species persisted in the Aquia Creek period. The specimen was collected on November 25, 1891.—L. F. W.

SEQUOIA CYCADOPSIS Fontaine.

Pl. CIX, Fig. 11.

1889. *Sequoia cycadopsis* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 243, pl. cxii, figs. 9, 9a, 10, 11, 11a; pl. cxiii, figs. 1, 1a, 2, 2a, 3.

This is a well-marked species that is highly characteristic of the Aquia Creek horizon. There was obtained from Rosiers Bluff a very good specimen that shows the terminal part of an ultimate twig with a number of well-preserved leaflets. The rock matter containing it is somewhat different from that showing most of the specimens of Rosiers Bluff, as it is an ash-gray pure clay.[a]

FOSSIL PLANTS FROM RIVERDALE.

[Pl. LXXX, No. 129.]

In the collections there are four clay casts of small cones credited to the locality Riverdale. This locality is a cut on the electric railroad between Hyattsville and Riverdale and about midway between these two places. The bed is referred to the Arundel formation. The cones appear to belong to *Athrotaxopsis expansa*. This small amount of material is of course not sufficient to determine positively the age of the beds yielding them, but, so far as their evidence goes, it confirms the assumption that it is Rappahannock or Arundel. The specimens were collected by Mr. Arthur Bibbins, three of them on July 1 and the remaining one on July 28, 1896. This last is much larger than the others. It was obtained by Mr. Bibbins on an excursion in company with Professor Ward, to whom it was given, and it was deposited by the latter in the National Museum. The others are the property of the Maryland State Geological Survey and bear its number, 8248.

[a] There is a shade of doubt as to whether this specimen actually came from Rosiers Bluff. The locality number, as often happens, had become detached and was lost before it was sent to Professor Fontaine. I am sure that I collected it myself in the soft clay, and I had trimmed the sides in the field with a knife that I carry for the purpose. I had also carefully worked out the impression with the proper tools. Finding it in the collection made by Mr. White and myself on November 25, 1891, without a number, I wrote the number plainly with a pencil on one of the smooth-cut surfaces, then dry and well adapted to be written upon. In this form it went to Professor Fontaine, but the difference in the character of the matrix did not escape him, and he made the above note on this fact. It is, indeed, wholly different from that of any other specimen from the Rosiers Bluff locality, and there is no essential difference in the matrix of any of the other specimens from this locality. I have carefully compared it with all the other collections described in this paper and it does not exactly agree with any of them, but is much nearer to that from the 72d Milepost and the bank near Brooke. As this species had previously been found only at the former of these last-named localities, it is possible that the specimen is from there. The horizon, however, is the same.—L. F. W.

FOSSIL PLANTS FROM NEAR BERWYN.

[Pl. LXXX, No. 127.]

The locality designated "The Electric R. R. cut, near Berwyn," referred on the label to the "base of the Arundel," has yielded a specimen of some plant which, however, is not determinable.

FOSSIL PLANTS FROM THE BEWLEY ESTATE.

[Pl. LXXX, No. 90.]

Three specimens come from the Bewley estate. The locality is described on the label accompanying them as "Bewley estate, Branchville, Md., Patuxent?"[a] They occur in an arenaceous yellow clay, which is not cleavable, and they are very obscure. One specimen each of *Dioonites Buchianus* (Ett.) Born.?, *Menispermites virginiensis* Font.?, and *Sphenopteris latiloba* Font.? were found here. None of them can be positively determined, and of course these plants have no value for the determination of the age of the beds which contain them. Indeed, correctly determined, their evidence would be contradictory, as *Menispermites virginiensis* belongs to the Aquia Creek horizon and *Dioonites Buchianus* to the James River and Rappahannock member. The specimens are all under one label with the number 3838, but the institution to which they belong is not indicated.

FOSSIL PLANTS FROM MUIRKIRK.

[Pl. LXXX, No. 101.]

In January, 1888, Mr. J. B. Hatcher, working under the direction of Prof. O. C. Marsh for the United States Geological Survey, collected in an iron-ore pit known as Coffin's engine mine, 1 mile south of Muirkirk, Md., 50 mud casts of small cones. He stated that they came from about 12 feet below the surface and were associated with vertebrate bones, of which he obtained the well-known collection described by Professor Marsh.

On May 19, 1891, another collection was made for the United States Geological Survey from the same mine, but wholly from the dump, the

[a] The bed yielding these plants is in the left bank of the Paint Branch above where the Metzerott road crosses it and near the Baltimore pike just above the bridge. The vertical bluff is 15 feet high and consists of paint clays and shales of lively pink and blue colors and well stratified. They seem to be a transgression of the Patapsco. The specimens, however, do not come from these clays, but from the coarser beds that overlie them.—L. F. W.

shaft being then filled with water. This collection was made by Lester F. Ward, David White, and Robert T. Hill. They obtained 42 of the cones, but these are less perfect than the others.

In 1893 Mr. Arthur Bibbins collected 1 specimen, No. 6342 of the Woman's College of Baltimore, and in June, 1895, he obtained for the State Geological Survey of Maryland 5 more of these same cones. These bear the number 5709 of that survey. On still another occasion he collected what seems to be a cycadaceous fruit.

The cones all seem to belong to *Athrotaxopsis expansa*, and the cycadaceous fruit is probably *Cycadeospermum acutum*.

ATHROTAXOPSIS EXPANSA Fontaine.

Pl. CIX, Figs. 12, 13.

1889. *Athrotaxopsis expansa* Font.: Potomac Flora (Monogr. U. S. Geol. Survey, Vol. XV), p. 241, pl. cxiii, figs. 5, 5a, 5b, 6; pl. cxv, fig. 2; pl. cxvi, fig. 5; pl. cxvii, fig. 6, pl. cxxxv, figs. 15, 15a, 15b, 18, 22 (cones).

As already remarked, the cones collected by Mr. J. B. Hatcher came from the clay which yielded the dinosaurian remains described by Professor Marsh from the Potomac strata of Maryland. These dinosaurian fossils led Professor Marsh to maintain that the Potomac formation of Maryland is of Jurassic age. The cones now in question are of additional interest on account of their unusual mode of fossilization. They are mud casts, and in most cases retain no trace of the original vegetable matter. They vary a good deal in size, but all seem to belong to the one species, *Athrotaxopsis expansa*. The largest are 18 mm. by 15 mm., and the smallest are not more than half as large. The difference in size is probably due to a difference in their development. They are often somewhat distorted from pressure. The normal shape seems to have been broadly oblong, but some are nearly spherical. The fossil is composed of indurated mud deeply pitted with depressions that sometimes take the exact form of the cone scales, and the whole object retains pretty accurately the shape and size of the original cone. Sometimes the pits retain a trace of carbonaceous matter, from the vanished scale, lining the pit. The pits were evidently caused by the decay of scales which persisted until the cone had been outlined in mud. These cones are exactly like those of *Athrotaxopsis*

expansa given in Monograph XV, pl. cxxxv, figs. 15, 18, 22, but here the material is clay. The clay retaining the shape of the cone has undergone some modification and induration not found in that which embeds it, for the mud cones may be picked out of the matrix retaining their shape. The pits are clearly not so numerous as the scales of the cones were originally. The precise mode of fossilization is not evident. It would seem that the ripened cones, retaining a few widely divergent and persistent scales, fell to the bottom and were buried in the accumulating mud sediment. Then the surrounding mud was pressed in between the scales and took the form of the cone. Afterwards the scales decayed and left pits to represent them. These pits sometimes give very well the shape of the vanished scale. They indicate that the ends of the scales had broad peltate forms, and that they, toward their insertion on the axis, were greatly attenuated.

The clay retaining the form of the cones seems to have been indurated, as stated before, so that the fossils can be separated from the surrounding mud. Probably this was caused by silica deposited from solution. The silica may have been brought into solution by the action on the surrounding rock material of the vegetable acids produced in the decay of the material of the cones. I have often observed indications of such action in other cases. For example, limbs of trees, once embedded, have been found now represented only by hollows or molds which take their form. The walls of the molds were impregnated with silica deposited from solution and were often so strengthened that the molds were kept open.

Pl. CIX, Fig. 12, represents one of the smallest, but not the smallest, of the cones, and Fig. 13 one of the largest. Both of these occur in Mr. Hatcher's collection and are deposited in the National Museum. As will be seen by the above account, there are in all the collections 98 specimens of these cones.

As above stated, Coffin's old engine bank, Muirkirk, also furnished Mr. Bibbins a single doubtful specimen of *C. acutum*. The label is marked "M. G. S., 9774."

In the collections of the Maryland Survey from the Muirkirk locality are several specimens of so-called white ore—that is, carbonate of iron—which show rootlets that can be identified with no species.

These fossils alone would not suffice to fix the age of the rocks yielding them, but do not oppose the assumption of the Arundel or Rappahannock age of the material.

FOSSIL PLANTS FROM CONTEE.

[Pl. LXXX, Nos. 95, 97.]

Two specimens come from near Contee, which is the next station northeast of Muirkirk, on the Baltimore and Ohio Railroad. The label accompanying one of these reads: "Peterson's mine, near Contee, Prince George Co., Md." (Pl. LXXX, No. 97), with no formation named. The fossil is a clay cast of a small cone which probably belongs to *Athrotaxopsis expansa* Font. It suggests that the age of the formation is Arundel, or, what is the same thing, Rappahannock. It is No. 8242 of the Maryland Geological Survey, collected by Mr. Bibbins in 1896.

The other is a specimen of *Cycadeospermum rotundatum* Font., credited on the label accompanying it to "Iron-ore clays, B. & O. R. R. cut, Contee, Maryland" (Pl. LXXX, No. 95). This species in the Virginia Lower Potomac[a] was found in only one specimen, in strata of Rappahannock age. So far as its evidence goes, it indicates that the clays yielding it belong to the Arundel. The label does not give date or collector, but it is marked "M. G. S., 8779."

FOSSIL PLANTS FROM ARLINGTON.

[Pl. LXXX, No. 73.]

This locality is half a mile north of the village of Arlington and a mile and a half east of Jessup station on the Baltimore and Ohio Railroad, on the high ground, nearly 300 feet above sea level, which forms the divide between the Patuxent and Patapsco drainages, through which passes the somewhat famous Jessup Cut. Several large collections were made by Mr. Bibbins from points only a short distance apart in this general region (see p. 389). These collections contain more specimens than were obtained from any other locality. They are, however, mostly duplicates of a comparatively small number of species. As the species show that the various localities belong to the same horizon, and as the rock matter containing them indicates that they come from the same

[a] Monograph XV, p. 271, pl. cxxxvi, fig. 12.

bed, or is at least the same material, no attempt will be made to treat the collections separately. Most of the fossils occur in limonite, and some in a ferruginous sandstone highly charged with limonite. The following is the list of species occurring here:

Abietites angusticarpus Font.	3 specimens.
Athrotaxopsis expansa Font.	57 specimens.
Athrotaxopsis tenuicaulis Font.	1 specimen.
Baieropsis adiantifolia Font.?	1 specimen.
Brachyphyllum parceramosum Font.	29 specimens.
Cephalotaxopsis ramosa Font.?	3 specimens.
Cladophlebis acuta Font.	400 specimens.
Cladophlebis acuta angustifolia Font. n. var.	115 specimens.
Cladophlebis alata Font.	2 specimens.
Cladophlebis Browniana (Dunk.) Sew.?	2 specimens.
Cladophlebis parva Font.?	1 specimen.
Cladophlebis Ungeri (Dunk.) Ward?	1 specimen.
Dioonites Buchianus (Ett.) Born.?	2 specimens.
Dryopteris angustipinnata (Font.) Kn.	13 specimens.
Dryopteris fredericksburgensis (Font.) Kn.	1 specimen.
Dryopteris parvifolia (Font.) Kn.	70 specimens.
Glyptostrobus (Taxodium) expansus Font. n. comb.	2 specimens.
Osmunda dicksonioides Font.?	1 specimen.
Pecopteris virginiensis Font.?	1 specimen.
Proteæphyllum oblongifolium Font.	1 specimen.
Rogersia longifolia Font.?	3 specimens.
Sequoia ambigua Heer.	9 specimens.
Sphenolepidium dentifolium Font.?	1 specimen.
Sphenolepidium Kurrianum (Dunk.) Heer.	1 specimen.
Sphenolepidium parceramosum Font.?	9 specimens.
Thinnfeldia marylandica Font. n. sp.	16 specimens.
Thyrsopteris pachyrachis Font.?	3 specimens.

Cladophlebis acuta Fontaine.

Pl. CXIV, Figs. 3, 4.

1889. *Cladophlebis acuta* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 74, pl. v, figs. 7, 7a; pl. vii, figs. 6, 6a; pl. x, figs. 6, 6a, 7, 7a; pl. xi, figs. 7, 7a, 8, 8a; pl. clxvi, figs. 5, 5a.

This plant was described in Monograph XV from a comparatively few specimens obtained from Virginia localities. It is very common at the Arlington localities, being much the most abundant species there.

In the different collections there are fully 400 determinable specimens. They are all fragments of pinnæ, mostly ultimate ones, with pinnules in various states of preservation and from different portions of the frond. In this large amount of material it is to be expected that more variation would be found than was shown in the Virginia specimens. Still, the species appears remarkably constant. A very small number of the specimens show on some of the largest pinnules a slight crenulate toothing. Some of the pinnules are larger than any in the Virginia forms. Some of them are narrower than the normal ones and approach in that respect the variety called in this paper *angustifolia*. Some of the larger and longer pinnules resemble *C. falcata*. This latter, however, quite constantly, has the lateral nerves of the pinnules deeply bifurcate. In *C. acuta* they are simply furcate. Only in a very few of the largest pinnules are they sometimes bifurcate. The lateral nerves in *C. acuta* are quite constantly forked near their insertion on the midnerve. They then diverge strongly and become subparallel before reaching the margin of the pinnule. Pl. CXIV, Fig. 3, gives some of the larger pinnules, and Fig. 4 some of unusual length in proportion to their width. The former of these is No. 5375 and the latter No. 5120 of the Woman's College of Baltimore.

CLADOPHLEBIS ACUTA ANGUSTIFOLIA Fontaine n. var.

Pl. CXIV, Fig. 5.

One of the most common plants at the Arlington localities is a fern with narrow pinnules, which in most respects closely resembles *C. acuta*. It differs from the latter only in the form of its pinnules. These are decidedly narrower in proportion to their length than those of the normal form. It is true that in some specimens the pinnules of the normal form, in some portions of the pinnæ, approach these in narrowness, but there are too many of these narrow ones and they are too constant in character to be regarded as sporadic variations in the normal type. These forms resemble also *Dryopteris angustipinnata*, presently to be treated. From this also it differs by constant features, which will there be pointed out.

In the collections made from the Arlington localities there are 115 specimens of this form. The variety *angustifolia* differs from the normal form in having pinnules narrower in proportion to their length and in

their more strongly falcate form. It is not unusual to find pinnules more than 2 cm. long with a width not greater than 5 mm. Pl. CXIV, Fig. 5, shows a portion of an ultimate pinna with pinnules of average character. In Maryland this fern and the normal form are confined to the Arlington localities. The specimen figured bears the number W. C., B., 5055.

CLADOPHLEBIS ALATA (PECOPTERIS STRICTINERVIS).[a]

In the Lower Potomac flora of Virginia two types of ferns were found and described in Monograph XV as distinct species. They are *Cladophlebis alata* and *Pecopteris strictinervis*. Recently forms have been found in Alaska (see p. 158) that make it probable that these are phases of the same species, for which the name *Cladophlebis alata* is retained. In the Arlington collections two specimens of the *Pecopteris strictinervis* type were obtained. The best of these shows a portion of an ultimate pinna with good pinnules. The plant was evidently quite rare here. The specimens are numbered W. C., B., 5045, 5048.

DRYOPTERIS ANGUSTIPINNATA (Fontaine) Knowlton.

Pl. CXIV, Fig. 6.

1889. *Aspidium angustipinnatum* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 98, pl. xvi, figs. 1, 3, 3a, 3b, 8, 8a; pl. xvii, figs. 1, 1a; pl. xix, fig. 10.

1895. *Dryopteris angustipinnata* (Font.) K.: Bull. U. S. Geol. Surv., No. 152, p. 91.

Thirteen specimens of *Dryopteris angustipinnata* were found among the plants from the Arlington localities. They are not so good as those described in Monograph XV, and no fructified forms were seen. The pinnules of this fern resemble somewhat the narrowest ones of *Cladophlebis acuta angustifolia*, but differ from them in important points. The pinnules of *Dryopteris angustipinnata* are narrower than those of *Cladophlebis acuta angustifolia* and have nearly the same width from their base to near their apex. They are less falcate and their lateral nerves are less commonly furcate. When forked they do not fork so near the midrib. Very commonly their lateral nerves are simple and parallel. In *C. acuta angustifolia* the pinnules are much wider at base and they

[a] Monograph XV, pp. 77, 78, pl. xix, fig. 5; pp. 84, 85, pl. xiii, figs. 6–8; pl. xix, fig. 9; pl. xx, fig. 3; pl. xxii, fig. 13; pl. clxx, figs. 5, 6.

are strongly falcate, with nerves as a rule furcate from near the midrib. The specimens of *Dryopteris angustipinnata* from the Arlington localities are small portions of ultimate pinnæ, sometimes showing well-preserved pinnules. One of the best specimens is shown in Pl. CXIV, Fig. 6. It bears the number W. C., B., 5035.

DRYOPTERIS PARVIFOLIA (Fontaine) Knowlton.

Pl. CXIV, Fig. 7.

1889. *Aspidium parvifolium* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 100, pl. xxi, figs. 6, 6a, 6b; pl. xxiv, figs. 8, 8a; pl. xxv, fig. 10; pl. xxvi, figs. 1, 1a, 14, 16, 16a, 17,

1895. *Dryopteris parvifolia* (Font.) Kn.: Bull. U. S. Geol. Surv., No. 152, p. 92.

This species was described in Monograph XV, from very imperfect small fragments, as coming from the Lower Potomac of Virginia. The amount of material from the Maryland Potomac is much larger and some of the fragments of this fern found in it are larger than any of the Virginia specimens, but still nothing but small portions of the plant were found. For this reason nothing of importance can be added to the diagnosis of the species.

This plant, like the two forms of *Cladophlebis acuta*, is in Maryland confined to the Arlington localities, where 70 specimens of it were obtained. Pl. CXIV, Fig. 7, shows the most complete form found. It is a considerable portion of a penultimate pinna with many imperfect ultimate pinnæ, and on many of the latter good pinnules are found. It bears the number W. C., B., 5059.

THINNFELDIA MARYLANDICA Fontaine n. sp.

Pl. CXIV, Figs. 8, 9.

At the Arlington localities, and nowhere else, a number of fragments of a fern were found that seems to be a new species. While the portions of the pinnæ of this plant are not very rare, 16 in all, they are so fragmentary that it is difficult to make out its character. On the whole, it agrees best with the genus Thinnfeldia, so far as can be determined from the imprints. Still, it is quite possible that better specimens would show that it belongs to some other genus. The most complete specimen, W. C., B., No. 5450, shows no more than a portion of a detached ultimate

pinna, or a lobed pinnule. This is represented in Pl. CXIV, Fig. 8. Fig. 9 gives two such fragments not so complete as that given in Fig. 8. These two, however, are so placed as to indicate that they were once attached to a common rachis, not now preserved. The pinnæ or lobed pinnules partly overlap. The parts that are preserved appear to be the terminal ones of the pinna or pinnules and they are not sufficiently well preserved to give their dimensions and shape. The nature of the incisions of the lamina, which represent either lobes or pinnules, can be made out and the nervation is remarkably distinct. This specimen is without number or locality label, but the Arlington material is so distinctive that there can be no doubt that it is from that locality.

The lobes or pinnules are very obliquely incised and are oblong in form, with the free ends obtuse lancet shaped. The incisions visible are not cut down to the midrib, but indicate that lower down on the portions shown they may be so, constituting pinnules. The midnerve or rachis of the pinna is distinct and somewhat flexuous. On each side of this midnerve parent nerves depart at a very small angle to enter the pinnæ or lobes. The parent nerve forks at long intervals, the principal branch of each fork keeping near the middle of the pinna or lobe, while the other branch forks some distance up. These minor nerves are quite remote from one another and sharply defined, though not very strong.

While this fern can not be fully made out, it is clearly different from any previously found in the Potomac beds. It is confined to the Arlington localities.

AGE OF THE ARLINGTON BEDS.

As was stated in the beginning of the account of the Arlington beds, the plants occur at different localities in a similar kind of rock and are generally the same, so that the presumption is that the fossiliferous beds at all of them are essentially the same. To determine their age, as compared with the divisions of the Virginia Lower Potomac, comparison must be made with the plants described in Monograph XV. The labels accompanying most of the fossils give the Maryland division as Patapsco. Those from one of the localities are given as Arundel.

If we omit from the list of plants found at these localities the new species and the doubtful forms, we have the following:

Abietites angusticarpus.
Athrotaxopsis expansa.
Athrotaxopsis tenuicaulis.
Brachyphyllum parceramosum.
Cladophlebis acuta.
Cladophlebis alata.
Dryopteris angustipinnata.
Dryopteris fredericksburgensis.
Dryopteris parvifolia.
Glyptostrobus (Taxodium) expansus.
Proteæphyllum oblongifolium.
Sequoia ambigua.
Sphenolepidium Kurrianum.

These, with the exception of the last one, as described in Monograph XV, are all confined to the horizon of the James River and Rappahannock series, which form the lowest portion of the Lower Potomac of Virginia. *Sphenolepidium Kurrianum*, though common in the lower beds, also occurs in the Brooke beds at the 72d Milepost, and at the bank near Brooke. But it is rare in the Arlington flora. These facts make it most probable that the Arlington beds are of the age of the James River and Rappahannock series, equivalent to the Arundel.

FOSSIL PLANTS FROM HANOVER.

[Pl. LXXX, No. 48.]

The collections from Hanover were all made by Mr. Arthur Bibbins, for the Maryland Geological Survey, and bear labels accordingly. Twelve specimens having determinable plant impressions were collected in June, 1896, and 1 in August, 1896, while 13 others bear no date. There is one specimen without a label, the material of which is identical with that of all but three of the others, and there can be no doubt that it is from the same bed. This material is an ash-gray clay, filled with small specks of lignite and other vegetable matter. Two of the specimens obtained in June, 1896, are of a different material, being lighter colored and sandy. These bear the numbers 8604 and 8607. One other collected at that date is a heavy ironstone of a bright-red color. This bears the number 8611. The 13 specimens whose labels are not dated are all from the same clay as the most of those that are dated. The specimens dated June, 1896, other than the three already mentioned, bear the following numbers of the State Survey: 8242, 8597, 8602, 8603, 8609, 8613, 8618, 8619, 8620. The specimen whose label is dated August, 1896, is numbered: M. G. S.,

5291. The 13 specimens whose labels bear no date are numbered: 8625, 8626, 8629, 8630, 8631, 8632, 8633, 8634, 8635, 8636, 8640, 8642, 8642 (two specimens bear this number). It is proper to add that a large proportion of the specimens from Hanover bear indeterminable impressions and are not included in the above enumeration, which accounts for missing numbers.

Although this collection is rather small, yet, owing to the character of the rock matrix, which preserves fairly well the plant material, a large proportion of the fossils can be determined, a feature that unfortunately is wanting in a good deal of the Maryland material.

The following are the species that occur in these collections:

Cladophlebis Browniana (Dunk.) Sew	1 specimen.
Dryopteris angustipinnata (Font.) Kn	22 specimens.
Frenelopsis parceramosa Font	1 specimen.
Glyptostrobus (Taxodium) ramosus Font.?	2 specimens.
Sphenolepidium Sternbergianum densifolium Font	1 specimen.

The evidence of these plants goes to indicate that the strata yielding them are of Arundel or Rappahannock age.

FOSSIL PLANTS FROM THE HOWARD BROWN ESTATE.

[Pl. LXXX, No. 51.]

Nine of the specimens from this locality show determinable impressions of plants. The rock material, with the exception of one specimen, is an ash-gray clay, practically identical with that of most of the specimens from the Hanover locality. The following species occur:

Athrotaxopsis expansa Font.?	3 specimens.
Cladophlebis alata Font.?	1 specimen.
Dryopteris angustipinnata (Font.) Kn	7 specimens.
Frenelopsis parceramosa Font.?	1 specimen.

This material is not sufficient to fix the age, but indicates that it is Arundel or Rappahannock.

FOSSIL PLANTS FROM REYNOLDS'S ORE PIT.

[Pl. LXXX, No. 29?]

The only specimen from this locality was collected by Lester F. Ward on June 24, 1894. It was found in a pile of dark-reddish rocks that had been taken out of the bottom of the mine. The specimen shows several poorly preserved bits of ultimate twigs of a conifer that is probably *Sequoia Reichenbachi* (Gein.) Heer.

FOSSIL PLANTS FROM GERMAN'S IRON MINE.

[Pl. LXXX, No. 53.]

In 1897 Mr. Arthur Bibbins collected at German's iron mine a specimen of light-colored clay which on being broken through revealed a raised seed on one of the pieces and the depression that it formed on the other. The form of the seed is obovate, and it is probably *Cycadeospermum obovatum* Font. One side of the piece that contains the depression made by the seed shows also a small male ament of some conifer, not very distinctly preserved. The label bears the number: W. C. B., 6304.

These specimens are not sufficient to fix the age of the bed, but so far as they are concerned it may well be Arundel, as indicated on the label.

FOSSIL PLANTS FROM HOBBS'S IRON MINE.

[Pl. LXXX, No. 58.]

There are three small collections from this locality, all made by Mr. Arthur Bibbins for the Maryland Geological Survey. One of them has the date 1897 on the label. It consists of a single rock specimen broken into three pieces. The rock is a heavy ferruginous sandstone, reddish brown without and dark within. The label bears the number: M. G. S., 8780. Another consists of a single rock specimen of the same character. There is no date on the label, but it has the number 8317. The third collection is from the dump opposite Hobbs's mine and contains two specimens of a somewhat different rock having a lower specific gravity. There is no date, but the number is 8872.

Only two species, both doubtful, can be recognized among these specimens. They are:

Athrotaxopsis expansa Font.?.....4 specimens.
Nageiopsis zamioides Font.?.....1 specimen.

FOSSIL PLANTS FROM TIP TOP.

[Pl. LXXX, No. 58.]

Three collections were made from this locality. The first consists of a single specimen obtained by Mr. Arthur Bibbins in 1890. The second contains a considerable number of specimens and was made by Mr. Bibbins and Professor Ward on August 31, 1896. This last is deposited in the

National Museum. The third was made by Mr. Bibbins for the Maryland Geological Survey in July, 1897. It is somewhat smaller than the one last mentioned.

The exact locality at which all these collections were made is the Mount Pleasant mine, near the foot of the hill called Tip Top that lies between Deep Run and Stony Run and overlooks the Patapsco Valley above Elkridge Landing. The mine is in a ravine, now thickly wooded, on the south or Stony Run side of Tip Top, and not far from that stream, west of a well-known spring. The mine has been long abandoned, and there is a pile of ferruginous rocks that were taken out of the old shaft. The original specimen collected by Mr. Bibbins in 1890, and the whole of the collection made by Mr. Bibbins and Professor Ward on August 31, 1896, were obtained by breaking up a single one of these rocks, which was the only one seen at that time in which plant impressions occurred.

The three collections taken together yielded the following species:

Athrotaxopsis expansa Font.?	4 specimens.
Athrotaxopsis grandis Font.?	1 specimen.
Athrotaxopsis tenuicaulis Font.?	1 specimen.
Sphenolepidium dentifolium Font.?	2 specimens.
Sphenolepidium Sternbergianum densifolium Font	16 specimens.

SPHENOLEPIDIUM STERNBERGIANUM DENSIFOLIUM Fontaine.[a]

Pl. CXV, Fig. 1.

Imprints of this species occur on most of the specimens from Tip Top. The one first obtained by Mr. Bibbins in 1890 (M. G. S., No. 8871) bears them, as well as those of *Athrotaxopsis expansa ?* The specimen figured on Pl. CXV, Fig. 1, was collected by Professor Ward and Mr. Bibbins on August 31, 1896. Its counterparts, showing the impression quite as well, was collected by Mr. Bibbins in July, 1897, and bears the number: M. G. S., 8283. Besides the ones already mentioned, the collections contain 14 others, making 16 altogether.

This collection is too small and imperfect to give the evidence from the plants much value in fixing the precise age, especially when the only fossil that is positively determined ranges from the base to the top of the Lower Potomac of Virginia. So far as the evidence goes, it indicates that the age of the strata is Arundel or Rappahannock.

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[a] See p. 507.

FOSSIL PLANTS FROM VINEGAR HILL.

[Pl. LXXX, No. 56.]

This locality is a cut on the Baltimore and Ohio Railroad about a mile east of Relay and immediately west of the bridge where that road passes over the Baltimore and Potomac Railroad. It is at the foot of a considerable hill, known as Vinegar Hill, which rises to the north of that point. The precise spot is nearly midway of the cut, though somewhat nearer its western end, on the north side of the tracks, beginning about 6 feet above the tracks and having a thickness of 4 feet. The water has here worn a small gulch, in the sides and bottom of which the plants occur. It was discovered by Mr. Arthur Bibbins, who, in October, 1895, made a considerable collection from it for the Woman's College of Baltimore. One specimen was collected by Mr. Bibbins on September 1, 1896, and the next day (September 2, 1896) a good collection was made by Mr. Bibbins and Professor Ward. This collection is deposited in the National Museum.

The fossiliferous rock material from this locality differs from that of all the others, though some of it closely resembles that of Federal Hill in Baltimore. It is a friable, fine-grained, sandy clay, with an imperfect cleavage, which is, however, better than that of the material from the other localities. Hence the preservation is better. But here also only small fragments of plants seem to have been preserved, probably owing to the fact that the place of entombment was remote from the place of growth. The plants in it are fairly well preserved as a rule, and some are quite distinct. As, however, the material is soft and friable, the plant impressions are easily destroyed.

The following is the list of species from this locality, with the number of specimens of each species:

Abietites angusticarpus Font	3 specimens.
Abietites ellipticus Font	10 specimens.
Abietites macrocarpus Font	18 specimens.
Abietites marylandicus Font. n. sp	1 specimen.
Athrotaxopsis expansa Font.?	1 specimen.
Celastrophyllum obovatum Font	1 specimen.
Cephalotaxopsis ramosa Font.?	1 specimen.
Cladophlebis Browniana (Dunk.) Sew.?	1 specimen.
Cladophlebis constricta Font	3 specimens.
Cladophlebis crenata Font	2 specimens.

Cladophlebis falcata Font.?	2 specimens.
Dryopteris angustipinnata (Font.) Kn.?	1 specimen.
Dryopteris fredericksburgensis (Font.) Kn	1 specimen.
Dryopteris heterophylla (Font.) Kn	8 specimens.
Ginkgo? acetaria Ward n. sp	1 specimen.
Leptostrobus longifolius Font	26 specimens.
Nageiopsis heterophylla Font	1 specimen.
Nageiopsis longifolia Font	25 specimens.
Nageiopsis recurvata Font.?	1 specimen.
Pecopteris virginiensis Font	8 specimens.
Selaginella marylandica Font. n. sp	1 specimen.
Sphenolepidium parceramosum Font	2 specimens.
Thyrsopteris nervosa Font.?	4 specimens.
Thyrsopteris rarinervis Font	2 specimens.
Vitiphyllum multifidum Font	1 specimen.
Williamsonia? Bibbinsi Ward n. sp	1 specimen.
Zamites tenuinervis Font.?	1 specimen.

Abietites macrocarpus Fontaine.

Pl. CXV, Figs. 2, 3.

1889. *Abietites macrocarpus* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 262, pl. cxxxii, fig. 7.

Eighteen cones that were apparently of great size and that seem to be referable to this species occur among the Vinegar Hill collections. They are usually very poorly preserved, so as to show only vague indications of an axis with often detached scales, placed so as to show a former attachment to the axis. The scales must have been thin and long, overlapping one another along the axis. These cones are much larger than those supposed to belong to *A. ellipticus*, and the proportionally great number of them would indicate that this was one of the most important and abundant plants in the flora of the Vinegar Hill locality. Pl. CXV, Figs. 2, 3 represent two cones, both of which occur on the same rock fragment. They may suffice to give an idea, the one of the length of the cone and the other of the length of the scales. This specimen was collected by Mr. Bibbins on September 1, 1896, and is No. 6333 of the Woman's College of Baltimore, but a note on the label states that it was presented to the Maryland Geological Survey by the Woman's College.

The plant occurs, although rarely, in the lower portion of the lower Potomac of Virginia.

ABIETITES MARYLANDICUS Fontaine n. sp.

Pl. CXV, Figs. 4, 5.

There are in the collection from Vinegar Hill two imprints, counterparts of a cone which is of somewhat doubtful character. It seems to be a cone of some Abietites, and may belong to *A. ellipticus*, being preserved in such a way as to give it a different aspect from that presented by most of the cones of that species. Still, it is so unlike any species of this genus hitherto described from the lower Potomac that it is most probable that it belongs to a new species for which the name *marylandicus* is proposed. The two impressions thus made of this cone show different aspects of it, so as to complete each other, and hence it it has been thought best to figure them both. One of the impressions is given in Pl. CXV, Fig. 4. The summit and left-hand margin are wanting, although apparently not much is missing. This cone is smaller than any of the *Abietites ellipticus*, which seems to be the nearest to it of hitherto described species. It is in form narrowly oblong, about 15 mm. wide, with perhaps the full width not shown. The length, with a little of the summit wanting, is 3 cm. It is covered with closely placed rhomboidal scars that are elongated in a direction transverse to the axis of the cone. A casual inspection would give the impression that these markings are the imprints of the shield-shaped tips of the cone scales, but a lens shows that they are probably the closed-up hollows, or molds, left on the decay of the scales which once occupied them. These compressed molds show striations, apparently made by the surface of the scales. The scales seem to have been thin and closely imbricated. There are several different kinds of cones that are suggested by this fossil. In general form it resembles the cone of some Zamia. It is also not unlike the cones of some Sequoias, and even Brachyphyllum is suggested. On the whole, however, it seems more nearly allied to some Picea, like *P. excelsa*. This cone is supported on a stem that is in proportion to its size remarkably stout. Three centimeters of the length of this is still preserved. The width of the peduncle is a little more than 5 mm. There are, on the same fragment of shale, a number of scattered detached leaves of *Leptostrobus longifolius*. Though the bases of some of these are hidden under the stem, they do not seem to

be attached to it, while the cone is quite different from those described by Heer to Leptostrobus.

The other face of the same cone shows a length of over 4 cm. and a width of about 12 mm. It has nearly the same shape as the side depicted in Pl. CXV, Fig. 4. It is, however, more nearly entire and seems to narrow slightly at the base and summit. The stout stem retains, however, something more of its original length. This reverse side shows no markings of cone scales, but presents simply a formless mass of vegetable matter, which represents it and gives its shape and dimensions. This is shown in Fig. 5. Both the specimens were collected by Mr. Bibbins in October, 1895, for the Woman's College of Baltimore, that represented in Fig. 4 being No. 6086, and that in Fig. 5 No. 6149, of the museum of that college.

CELASTROPHYLLUM OBOVATUM Fontaine.

Pl. CXV, Fig. 6.

1889. *Celastrophyllum obovatum* Font.: Potomac Flora (Monogr. U. S. Geol. Surv. Vol. XV), p. 307, pl. clxxii, figs. 9, 10, 10a.

This plant is represented at Vinegar Hill by only one specimen. This, taken in connection with the specimen of *Vitiphyllum multifidum* which occurs on the same piece of shale, seems to connect this flora with that of Federal Hill in Baltimore. The specimen was collected by Mr. Bibbins in October, 1895, and bears the number 6154 of the museum of the Woman's College of Baltimore. The imprint is that of a small, nearly circular leaf, one side of which is preserved, but the base and part of the other side are wanting. It is shown in Pl. CXV, Fig. 6.

DRYOPTERIS HETEROPHYLLA (Fontaine) Knowlton.

Pl. CXV, Figs. 7, 8.

1889. *Aspidium heterophyllum* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 96, pl. xiv; pl. xv, figs. 1, 1a, 2, 3, 3a, 4, 4a, 5, 5a.
1895. *Dryopteris heterophylla* (Font.) Kn.: Bull. U. S. Geol. Surv., No. 152, p. 92.

A common fern at this locality is a plant that is identical with *Dryopteris heterophylla,* a form that is characteristic of the Fredericksburg locality of Virginia. It is preserved here with sufficient distinctness to admit of its certain identification. Pl. CXV, Fig. 7, gives a con-

siderable portion of the termination of a penultimate pinna, with a number of ultimate pinnæ and pinnules. This specimen retains only the imprint of outlines on pale-pink, friable, sandy shale, the material which at this locality gives the best fossils. None of the vegetable substance is retained. Pl. CXV, Fig. 8, represents, in the same kind of rock material, a portion of a principal rachis with several minor pinnæ attached, carrying ultimate pinnæ reduced to pinnules. The latter, in some cases, are very distinctly preserved. Both the specimens figured were collected on September 2, 1896, and are in the National Museum.

GINKGO ? ACETARIA Ward n. sp.[a]

Pl. CVIII, Fig. 12.

Seed of Ginkgo. ? The only trace of a probable Ginkgo in the flora of the Lower Potomac of Maryland is shown in a nut-like seed which may, however, really be a seed of Baieropsis. It is a nutlet, 12 mm. long and 9 mm. wide. It is smooth on the surface, with traces of the former fleshy envelope. In shape it is broadly oval, and is narrowed to a short beak at one end, or rather to an acute point, the point being much like the tip of the seed of the living *Ginkgo biloba*. It is smaller than the seed of *G. biloba*, but is decidedly larger than the small ones of the Ginkgos of the Jurassic of Oregon, described in this paper (see p. 126, Pl. XXXIII, Figs. 12–19). The trace of the fleshy envelope is in the form of a depressed rim around the seed. The specimen was collected by Mr. Bibbins in October, 1895, and is No. 6084 of the museum of the Woman's College.

LEPTOSTROBUS LONGIFOLIUS Fontaine.

Pl. CXVI, Fig. 1.

Twenty-six specimens of a plant which is certainly *L. longifolius* were found at this locality. The species ranges from the bottom to the top of the Lower Potomac strata of Virginia. It is most abundant in the beds of the Dutch Gap locality, which are slightly lower than those showing plants at Fredericksburg. Pl. CXVI, Fig. 1, represents the most complete specimen. This shows a number of tufts of linear leaves,

[a] Professor Fontaine assigns no specific name to this form. From principles that I have frequently set forth it should have one, however provisional, and I name it in allusion to the locality.—L. F. W.

which are grouped as if they had gone off from an ultimate twig not now present, and also, on the right, the end of an ultimate twig, from which two bundles of linear leaves proceed. It was collected September 2, 1896, and is deposited in the National Museum.

NAGEIOPSIS RECURVATA Fontaine?

Pl. CXVI, Fig. 2.

1889. *Nageiopsis recurvata* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 197, pl. lxxv, fig. 2; pl. lxxix, fig. 4; pl. lxxx, fig. 3.

Several leaves of a Nageiopsis that is much like *N. recurvata* occur on the same rock fragment that contains the more imperfect cone of *Abietites marylandicus*. (W. C., B., No. 6149, see Pl. CXV, Fig. 5.) One of the leaves is nearly entire. It has the dimensions and the peculiar curvature of the leaves of *N. recurvata*, as given in the specimens from the Lower Potomac of Virginia. It is regarded as doubtful only because the curved nature of the leaf may be accidental, and it may be simply a large leaf of *N. zamioides*.

PECOPTERIS VIRGINIENSIS Fontaine.

Pl. CXVI, Figs. 3, 4.

1889. *Pecopteris virginiensis* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 82, pl. viii, figs. 1, 1a, 2, 2a, 2b, 3, 3a, 4–7, 7a; pl. ix, figs. 1, 1a, 2, 2a, 3–6; pl. xxiv, figs. 2, 2a; pl. clxix, fig. 3.

Eight specimens of a fern that can be certainly identified with *P. virginiensis* of the Lower Potomac of Virginia were found at Vinegar Hill. This is the most abundant fern found here in these collections and some of the specimens are well enough preserved to show very distinctly its character. The most complete forms show only fragments of pinnæ carrying a number of serrately toothed pinnules. Pl. CXVI, Fig. 3, shows the best of these. It was collected on September 2, 1896, and is deposited in the National Museum.

In Mr. Bibbins's collection for the Woman's College of Baltimore *P. virginiensis* occurs in two specimens formed of portions of penultimate pinnæ with pinnules fairly well preserved. One of these specimens (Pl. CXVI, Fig. 4) appears to be fructified, but if so the fructification is too obscure to be made out. This specimen is No. 6169 of the Museum of

the Woman's College of Baltimore. This fern is the most abundant fossil in the collection made by Professor Ward and Mr. Bibbins. *P. virginiensis* has a character which, even in small specimens, may be easily distinguished. It is widely distributed both areally and vertically in the Lower Potomac formation of Virginia, being found in the highest and the lowest beds. It is most common at the Virginia locality "Roadside near Potomac Run," on the Fredericksburg or Rappahannock horizon.

SELAGINELLA MARYLANDICA Fontaine n. sp.

Pl. CXV, Figs. 9, 10.

The specimen found at the Vinegar Hill locality of this new species of Selaginella is quite distinctly preserved, so as to show its character well. The parts shown are several small fragments of penultimate twigs. The penultimate branch forks in a dichotomous manner sympodially, one branch in the forking being more developed than the other and continuing the twig, giving renewed branching. The minor branch in each case becomes an ultimate one. The longest of the penultimate twigs is only 12 mm. long, while the width, including the leaves, is only 2 mm. The leaves shown are minute in size, arranged in two rows, expanded in the same plane, and laterally attached. No leaves show on the upper surface, perhaps because they were carried away in splitting the shale. The lateral nerves are leathery in texture and well preserved. They have a distinct midnerve and are attached by a narrowed portion of the base. They are slightly cordate at base and are widest near the base. In general form they are ovate-acuminate and terminate with a well-preserved awn. The leaves are sometimes slightly falcate. The specimen is shown natural size in Pl. CXV, Fig. 9, and enlarged three diameters in Fig. 10. It was collected by Mr. Bibbins in October, 1895, and is No. 6148 of the Woman's College.

VITIPHYLLUM MULTIFIDUM Fontaine.

Pl. CXIX, Fig. 5.

1889. *Vitiphyllum multifidum* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 309, pl. clxxxii, figs. 1–9.

As above remarked, this specimen, the only one found at Vinegar Hill, occurs on the same piece of shale as the *Celastrophyllum obovatum*. It is noteworthy as being the only case of the occurrence of this species

outside of the Baltimore localities. Taken with the specimen of *Celastrophyllum obovatum*, a noteworthy connecting link with the Baltimore beds is given. The rock specimen, as stated, was collected by Mr. Bibbins in October, 1895, and is No. 6154 of the Woman's College museum.

WILLIAMSONIA? BIBBINSI Ward n. sp.[a]

Pl. CXV, Fig. 11.

The probable Williamsonia depicted in Pl. CXV, Fig. 11, shows a portion of an apparent axis of inflorescence and the basal parts of what seem to be a number of bracts surrounding it. It may be a cone of Abietites compressed vertically so as to shorten the axis. It was collected in October, 1895, and is W. C., B., No. 6087.

The above account of the plants collected by Professor Ward and Mr. Bibbins from the Vinegar Hill locality justifies the opinion that the age of the beds is that of the lower portion of the Lower Potomac as found in Virginia—that is, that it corresponds to the Fredericksburg strata, called in Professor Ward's subdivision the Rappahannock series. There are no plants in the list that are opposed to this opinion. As the Arundel group of the Maryland subdivision of the Lower Potomac, judging from the plants credited to it on the labels, corresponds with this Fredericksburg or Rappahannock member, the evidence of the plants indicates clearly that the Vinegar Hill beds belong to that division.

FOSSIL PLANTS FROM SOPER HALL.

[Pl. LXXX, No. 61.]

This locality is an old, abandoned system of iron mines, once extensively worked and covering a large area in a bold prominence on the right bank of the Patapsco, about 2 miles below Elkridge Landing and 1 mile below the crossing of the Baltimore and Potomac Railroad at Patapsco station. The determinable material obtained from this locality represents five different collections, viz:

1. In June, 1892, Messrs. Arthur Bibbins and H. H. Hindshaw collected 16 cones for the Woman's College of Baltimore.

2. Two specimens, one a cone, were collected by Mr. Bibbins for the same institution in June, 1892.

[a] Professor Fontaine left this form specifically unnamed. It was collected by Mr. Bibbins and may be named for him.—L. F. W.

3. In 1895 (the month not stated on the label) Mr. Bibbins collected 4 more of the cones, also for the Woman's College.

4. Five specimens were collected by Mr. Bibbins for the Maryland State Geological Survey, bearing the numbers of that survey, 8870, 8873–8876. The first of these bears also the date, 1895. The rest have no date, but are uniform with this in all other respects, and were probably obtained at the same time.

5. On August 31, 1896, Mr. Bibbins and Professor Ward made collections at several points in this region, and 3 determinable specimens were collected on the south side of the hill. It was near here, at a little higher level, that the same party obtained on March 29, 1894, a nearly erect trunk which was silicified in the interior above and lignitized on the exterior, while the lower end consisted entirely of lignite and had been used in part for fuel.

The iron rock at this locality, like the ferruginous sand rock of the Tiptop mines above described, is sand impregnated with limonite so as to form a pretty firm rock. The material being coarse and without cleavage is not suited for the preservation of fossil plants, and at the same time the plants seem to have been floated for some distance and roughly used. For these reasons the impressions are those of small fragments that are in general not distinct. The conditions under which they have been preserved have probably acted to exclude all forms that are easily destroyed, and hence the species are fewer than they would otherwise be and there is a great predominance of such as could endure.

Some of the specimens can not be determined, but there are others which can be made out. The following are all the species that can be determined from Soper Hall, with the number of specimens of each:

Athrotaxopsis expansa Font.?	3 specimens.
Sequoia ambigua Heer	21 specimens.
Sphenolepidium dentifolium Font.?	1 specimen.
Sphenolepidium Sternbergianum densifolium Font	5 specimens.

SEQUOIA AMBIGUA Heer.[a]

Pl. CX, Fig. 13.

The most important fossils are cones in the form of mud casts, 21 of which were found. These include all the cones of the first, second, and third collections described above. They are more or less distorted, and the plant matter had evidently in part been removed before the mud took the casts. These cones are decidedly larger than the cones of

[a] See p. 264.

Athrotaxopsis, but agree well with those of *Sequoia ambigua*, to which they probably belong. Pl. CX, Fig. 13, gives one of the best of these. It belongs to the first collection, all the specimens of which have the same label and the number W. C. B., 6271.

These forms justify the conclusion that the age of the strata at Soper Hall is Arundel or Rappahannock.

FOSSIL PLANTS FROM LANSDOWNE.

[Pl. LXXX, No. 62.]

ABIETITES ANGUSTICARPUS Fontaine.

Pl. CXIV, Fig. 10.

1889. *Abietites angusticarpus* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 263, pl. cxxxiii, fig. 1.

The locality here called Lansdowne is the same as Schoolhouse Hill, in which the Link trunk occurs (see p. 431), previously referred to as near Arbutus. In fact it is about midway between Lansdowne, on the Baltimore and Ohio Railroad, and Arbutus, on the Baltimore and Potomac Railroad. The formation is supposed to be Arundel. Here Mr. Bibbins collected for the Woman's College of Baltimore a cone of *A. angusticarpus* Font. This is a dissected cone of poor preservation, showing the axis of most of the cone and the bases of a number of scales fairly well. It occurs in a hard ferruginous sandstone. Pl. CXIV, Fig. 10, gives this cone. The shape and size are well shown in this specimen. It bears the number W. C. B., 6324.

FOSSIL PLANTS FROM FEDERAL HILL.[a]

[Pl. LXXX, No. 36.]

All the plants treated in this paper from the Federal Hill region, and probably all that had been previously described, were taken from clay pits and street excavations at the foot of Federal Hill in Baltimore, south of the basin and east of the park in which Federal Hill is located. The localities are all on or near Covington, Clement, and Jackson (formerly Belt) streets. The collections, mentioned in their chronological order, are as follows:

1. Three specimens were collected by Professor Ward on Jackson street on May 27, 1892.

[a] For the history of discovery at this locality see p. 362, also Monograph XV, pp. 4, 24, 25, 28, 29.

2. One specimen collected by Prof. P. R. Uhler has his name and the words "Behind Federal Hill, Baltimore," pasted on the rock.

3. One specimen collected by Professor Uhler in April, 1894, was donated by him to the National Museum through Professor Ward on April 11, 1894.

4. Some specimens without date bear numbers of the Woman's College of Baltimore. They were collected by Mr. Arthur Bibbins.

5. Mr. Bibbins made a collection from Covington and Clement streets in 1895 for the Woman's College.

6. At the Baltimore Terra Cotta Works, the clay for which is obtained from the Federal Hill region, Mr. Bibbins obtained many specimens for the Woman's College from 1898 to 1900.

7. Mr. Bibbins made a collection from Covington and Clement streets in 1898 for the Maryland Geological Survey.

8. The largest collection is that of Mr. Bibbins, from the streets last named, for the State Survey, the labels of which bear date February, 1899.

The following species occur in all these collections:

Acrostichopteris longipennis Font.	57 specimens.
Acrostichopteris parvifolia Font.	19 specimens.
Adiantites parvifolius Font. n. sp.	1 specimen.
Brachyphyllum crassicaule Font.	3 specimens.
Celastrophyllum latifolium Font.	12 specimens.
Celastrophyllum ? marylandicum Font. n. sp.	1 specimen.
Celastrophyllum obovatum Font.	17 specimens.
Cladophlebis alata Font.	1 specimen.
Cladophlebis Browniana (Dunk.) Sew.	2 specimens.
Equisetum marylandicum Font. ?	1 specimen.
Leptostrobus longifolius Font.	2 specimens.
Menispermites tenuinervis Font.	4 specimens.
Menispermites virginiensis Font.	1 specimen.
Nageiopsis angustifolia Font.	8 specimens.
Nageiopsis heterophylla Font.	4 specimens.
Nageiopsis longifolia Font. ?	2 specimens.
Plantaginopsis marylandica Font. n. sp.	5 specimens.
Proteæphyllum dentatum Font.	15 specimens.
Proteæphyllum Uhleri Font. n. sp.	1 specimen.
Sphenopteris latiloba Font. ?	1 specimen.
Thyrsopteris elliptica Font. ?	1 specimen.
Thyrsopteris Meekiana Font.	1 specimen.
Thyrsopteris Meekiana angustiloba Font.	1 specimen.
Thyrsopteris pachyrachis Font.	5 specimens.

Thyrsopteris rarinervis Font	1 specimen.
Vitiphyllum multifidum Font	150 specimens.
Vitiphyllum parvifolium Font	7 specimens.
Ament of conifer (*b*) Font	1 specimen.

ACROSTICHOPTERIS PARVIFOLIA Fontaine.

Pl. CXVI, Fig. 5.

1889. *Acrostichopteris parvifolia* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 108, pl. xciv, figs. 5, 5a, 9, 9a, 10, 10a, 12, 12a; pl. clxxi, figs. 3, 3a, 4, 4a; pl. clxxii, fig. 14.

This species, although not so common as *A. longipennis*, is one of the more abundant fossils, 19 specimens being found. As will be gathered from the description of it given in Monograph XV, it is most abundant in the lower strata of the Lower Potomac of Virginia. Like *A. longipennis* the specimens are mostly fragmentary. A few of them, however, are more complete than any in the Virginia specimens. Pl. CXVI, Fig. 5, gives one of the best of these. It occurs in collection No. 5 and bears the number 5959 of the museum of the Women's College of Baltimore.

ADIANTITES PARVIFOLIUS Fontaine n. sp.

Pl. CXVII, Fig. 1.

In collection No. 5 is found a single specimen of what seems to be a species of fern not hitherto described from the Lower Potomac. It resembles somewhat *Thyrsopteris brevipennis* Font., from the Lower Potomac of Virginia. Unfortunately not enough of it has been found to enable one to make out its full character. It is well known that the foliage of ferns varies much in the different parts of the same frond, and the material possessed may give a very incomplete idea of the plant. It is a fragment of a penultimate pinna. It carries several ultimate pinnæ, which mostly have the tips wanting. These pinnæ are short and indicate that the plant was of small dimensions. The pinnules are small and rounded in shape or broadly elliptical. They are narrowed to the base by which they are attached. Each pinnule has a parent nerve which enters its base and splits up into a number of forking branches. These diverge flabellately to fill the lamina. Pl. CXVII, Fig. 1, represents the specimen which bears no number.

CELASTROPHYLLUM LATIFOLIUM Fontaine.

Pl. CXVI, Fig. 6.

1889. *Celastrophyllum latifolium* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 306, pl. clxxii, figs. 3, 6; pl. clxxiii, figs. 13, 13a.

This species was described in Monograph XV as quite common at Belt and Covington streets, Baltimore. In the Covington and Clement streets collections, made by Mr. Bibbins, it is rather abundant, being more so than *C. obovatum*. The specimens are subject to much distortion, which has disguised their shape. The leaves vary a good deal in size, some being much larger than others. In shape they are mostly broadly elliptical. Twelve specimens were obtained from Covington and Clement streets. Pl. CXVI, Fig. 6, gives a portion of a leaf that must have been 4 cm. wide in its widest part. It belongs to collection No. 8 and bears the number M. G. S., 8569.

CELASTROPHYLLUM ? MARYLANDICUM Fontaine n. sp.

Pl. CXVI, Fig. 7.

Among the fossils from the Terra Cotta Works (collection No. 6) there is the imprint of a leaf that seems to be a new species of Celastrophyllum. As, however, it is unfortunately shown in only a single imperfect leaf, its full character can not be made out, and even its generic position must be left in doubt. The fossil is a fragment of a leaf that has its left-hand margin preserved to near the original base and summit of the leaf. The extreme base and summit and most of the right-hand margin are wanting. The part preserved shows a length of 7 cm., hence the leaf was much longer than any of the leaves of Celastrophyllum hitherto described from rocks on this horizon. The aspect of the leaf indicates that when entire it was elongate-elliptical in form. The margins have shallow teeth that resemble in form those of *Proteæphyllum dentatum*. The nervation is obscure. Some thin secondary nerves may be seen going off very obliquely from the midrib, and they resemble the nervation of a Celastrophyllum more than that of Proteæphyllum. The specimen bears the number W. C., B., 6096.

CELASTROPHYLLUM OBOVATUM Fontaine.[a]

Pl. CXVII, Figs. 2, 3.

Celastrophyllum obovatum was described in Monograph XV as coming from Belt and Covington streets, Baltimore, and was noted as one of the common dicotyledons there. It has not been found in the Potomac outside of Maryland. Seventeen specimens occur in the later collections from Federal Hill, some of them quite well preserved. Pl. CXVII, Fig. 2, gives a nearly complete leaf of the smaller size. This belongs to collection No. 8 and bears the number M. G. S., 8569. One of the specimens in collection No. 6 shows very well the middle and terminal portion of a leaf, and for this reason it is given in Pl. CXVII, Fig. 3. It gives the nervation also with unusual distinctness. It is W. C., B., No. 6099.

NAGEIOPSIS ANGUSTIFOLIA Fontaine.

Pl. CXVII, Figs. 4, 5.

1889. *Nageiopsis angustifolia* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 202, pl. lxxxvi, figs. 8, 9; pl. lxxxvii, figs. 2, 2a, 3–5, 5a, 6, 6a; pl. lxxxviii, figs. 1, 3, 4, 6–8; pl. lxxxix, figs. 2, 2a.

A fine specimen of the fossil first described in the Lower Potomac flora of Virginia as *Nageiopsis angustifolia*, which is one of the most widely distributed plants of the formation, was obtained by Professor Uhler at Federal Hill, Baltimore, collection No. 3, from the lowest horizon shown there, which is below that of the beds carrying *Acrostichopteris longipennis*. It is shown in Pl. CXVII, Figs. 4 and 5. This horizon at Baltimore, so far as is known to me, has yielded very few plants, hence this fossil is of unusual importance. Unfortunately, its range, which is throughout the Lower Potomac formation, impairs its value for fixing precise horizons. The specimen now in question shows on one side of the rock fragment three considerable portions of ultimate twigs having many leaves, some entire. One twig shows a portion near its termination (see Fig. 5). The opposite side of the rock has the end of an ultimate twig with a number of well-preserved entire leaves (see Fig. 4). The exact locality for this specimen is Jackson

[a] See p. 550.

street, near Federal Hill, lowest "vein" in Weaver's clay pit. The rock matter carrying the imprint is different from that holding the Acrostichopteris on Jackson street and indicates a different horizon. It is not the friable sandy clay carrying Acrostichopteris, but a plastic ash-gray clay, like some of that common in the Lower Potomac of Virginia on the horizon of the Rappahannock or Fredericksburg strata.

Seven specimens of *N. angustifolia* occur in Mr. Bibbins's collections from Federal Hill. One of these is a good imprint of a bit of a penultimate twig, and the rest are fragments of ultimate twigs with poor leaves.

It is a noteworthy fact that this species of Nageiopsis in the Virginia Potomac shows generally much better preserved and more entire forms than do the other species of this genus.

NAGEIOPSIS HETEROPHYLLA Fontaine.

Pl. CXVII, Fig. 6.

1889. *Nageiopsis heterophylla* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 201, pl. lxxxiv, fig. 4; pl. lxxxvi, figs. 6, 6a, 7; pl. lxxxviii, figs. 2, 2a, 5.

This species is represented in the Covington and Clement streets collections by 4 specimens. One of these, occurring in collection No. 5, is an imprint with a number of good leaves that are suddenly diminished in size toward the end of the twig. It is shown in Pl. CXVII, Fig. 6, and is W. C., B., No. 5987. While *N. angustifolia* is more common in the upper or Aquia Creek portion of the Lower Potomac in Virginia, this species is there confined to the lower portion of it.

Genus PLANTAGINOPSIS Fontaine n. gen.

Characters of the type species described below.

PLANTAGINOPSIS MARYLANDICA Fontaine n. sp.

Pl. CXVII, Fig. 7; Pl. CXVIII, Figs. 1, 2.

Among the specimens in collection No. 8, obtained at Covington and Clement streets, certain impressions are found, 5 in number, that seem different from any of the rest occurring here and which indicate the existence of a new genus and species. They occur sparingly and

are poorly preserved, so that the true character of the plant can not perhaps be made out. The basal portions of the leaves are the parts most commonly shown. Only in rare cases are parts toward the middle of the leaves found. The most complete leaf is given in Pl. CXVIII, Fig. 1. This indicates that the leaves were narrowly elliptical to linear in form, narrowing gradually to a clasping base, without petiole. The margins for some distance above the base seem to have been entire, but toward the ends of the parts preserved—which are not the terminations of the entire leaves—there are indications of shallow serrate teeth. The presence of teeth, however, is uncertain, owing to the imperfect preservation of the leaves. The nerves are not very well shown. There was certainly no midrib, and no prominent nerves in the form of ribs existed. The nerves as shown are few and remote. They run in a straggling manner through the length of the leaf and are approximately parallel. They seem to have been immersed in the cellular tissue. The leaves seem to have grown in a clasping manner, and in a cluster, from a rootstock. By the side of this leaf is an impression of an inflorescence which can scarcely be that of any other plant. This specimen is in counterparts, and the inflorescence is even more distinct on the other piece. The apparent rootstock is shown in Pl. CXVIII, Fig. 2, where a number of leaves are to be seen grouped around a vaguely defined stem. The leaves appear to have been succulent, with but little fibro-vascular tissue. The specimen represented in Fig. 1 bears the number M. G. S., 8559, and that in Fig. 2, 8541.

There was obtained from Covington and Clement streets a fragment of shale that bears the imprint of a plant that has a leaf of the general character of Plantaginopsis. This may be a more robust form of *P. marylandica*, or a different species. It may also belong to a genus different from Plantaginopsis, although this is not probable. The points in which it resembles Plantaginopsis are several. The specimen shows several fragments of leaves, which are grouped as if coming from a common rootstock. One of these shows preserved a good deal more of its length than the rest. This indicates that the leaves of this plant were at least twice as long and wide as the others. The largest fragment is about 15 cm. long, with much of the original length wanting. The maximum width shown is about 3 cm. The fragment narrows toward the base to about 8

mm., the true base not being shown. There are indications on the sides of teeth of the same nature as in *P. marylandica*. The fragment is somewhat puckered longitudinally, which obscures the nerves. The latter seem to be more numerous and more closely placed in the central part of the leaf than they are in *P. marylandica*, and to be stronger here. This specimen is shown in Pl. CXVII, Fig. 7.[a]

The true place of this peculiar plant is doubtful. In a number of points it resembles some forms of Plantago, and it may be compared with *P. virginica* L. From this resemblance the generic name is formed. The inflorescence also seems to indicate an affinity with Plantago. Several specimens show this inflorescence. The most complete form is given in Pl. CXVIII, Fig. 1, which shows an oblong elliptical imprint of a spike-like form, borne on a peduncle which is only partially preserved. This is associated with leaves of the plant now in question. In Fig. 2, similar forms, mounted on long, slender, naked scapes, may be seen attached to the rootstock from which the leaves arise. Those seen in Fig. 2 are incomplete, the tops being broken off. The one given in Fig. 1 is nearly entire and is oblong elliptical in form, with a length of 22 mm. and a width of 12 mm. It seems to have been a chaffy spike, but it is not well enough preserved for the details to be made out. The peduncles, as shown in Fig. 2, are at least 4 cm. long and not more than $1\frac{1}{2}$ mm. wide. In shape this spike agrees pretty well with an undeveloped spike of *Plantago virginica* L. Fig. 2 gives the most complete specimen of the plant, as it shows the rootstock with leaves and scapes rising from it.

PROTEÆPHYLLUM DENTATUM Fontaine.

Pl. CXVIII, Figs. 3, 4.

1889. *Proteæphyllum dentatum* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 286, pl. clvi, fig. 7; pl. clxxii, figs. 1, 4; pl. clxxiii, figs. 12, 14.

Fifteen specimens of *Proteæphyllum dentatum* occur in the collections now being described. They are in the form of more or less complete, detached leaves. Some of these are more complete than those described in Monograph XV. The leaves of this plant, as there stated, are among

[a] Professor Fontaine was in doubt as to whether this specimen really belonged to *P. marylandica*, and left it undetermined. An examination of the specimens in the light of the drawings leaves no doubt in my mind on this point, and I take the responsibility of including it.—L. F. W.

the most abundant at Belt and Covington streets in Baltimore. For some reason they are better preserved than most of the dicotyledons occurring at the Baltimore localities. The more perfect specimens found in the collections made by Mr. Bibbins give a more accurate idea of the plant than could be obtained from the fossils serving as the basis of the description given in Monograph XV. Pl. CXVIII, Figs. 3, 4, give two of the leaves that show most character. Fig. 3 represents a portion of a leaf of the largest size. The basal part is wanting, but the terminal portion is well preserved, showing most of the teeth. This leaf, in its widest part, which is below the middle, is at least 5 cm. wide. It narrows very gradually toward its summit, so that a rounded form is indicated for the entire leaf. Fig. 4 shows more of the base, which is still imperfect, and in this specimen is somewhat distorted. A portion of the petiole is preserved, which indicates that it must have been broad and flat. There seems to have been no predominant midrib, but several rather slender primary nerves of nearly equal strength diverge from the summit of the petiole to fill the lamina of the leaf. The ultimate nervation is as described on page 287 of Monograph XV.

Both the specimens figured occur in collection No. 8, that represented in Fig. 3 being M. G. S., No. 8593, and that in Fig. 4 No. 8556.

PROTEÆPHYLLUM UHLERI Fontaine n. sp.

Pl. CXVIII, Fig. 5.

This is a complete leaf of what seems to be a new species of Proteæphyllum. The leaf has entire margins and a rather thick texture. It is wider than long, with a broadly elliptical form, the elliptic shape being transverse to the axis of the leaf. In the widest part, which is near the base, it is a little over 4 cm. wide. Its length is a little more than 3 cm. At the base there is a slight decurrence of the lamina along the petiole. The midrib continues about halfway up the lamina of the leaf and is dissolved into the tertiary nerves, which form an irregular, coarse, polygonal network. The lateral or secondary nerves occur only in the basal part of the leaf. They are indefinite in form, and quickly dissolve into tertiary nerves, which, like those at the summit of the leaf, form an irregular network. The tertiary are almost as strong as the secondary nerves. The latter, indeed, can be distinguished by their size from the former only at

their insertions on the midrib. The tertiary nervation can not be distinctly seen.

The specimen on which this imprint occurs constitutes collection No. 2. The rock matter carrying the plant is identical with that from Jackson street, which contains *Acrostichopteris longipennis*, and no doubt the stratum yielding both the species is the same.

This species is named for its discoverer, Prof. P. R. Uhler. The specimen is deposited in the National Museum.

THYRSOPTERIS MEEKIANA Fontaine.

Pl. CXIX, Fig. 1.

1889. *Thyrsopteris Meekiana* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 125, pl. xxxviii, figs. 2, 2a, 2b, 3, 3a, 4, 4a, 8; pl. l, figs. 7, 7a, 8; pl. li, figs. 3, 3a.

This species is shown in one good specimen from the Terra Cotta Works, collection No. 6. It is described in Monograph XV as one of the most abundant plants collected by Professor Meek at an unknown locality in Baltimore. This specimen, shown in Pl. CXIX, Fig. 1, is the terminal part of a penultimate pinna with a good many ultimate ones bearing pinnules. It gives a part of the fern not shown in any of the specimens figured in Monograph XV. This fossil shows that in the fern, toward the summit of the compound pinnæ, the pinnules lose their lobing and become entire, passing finally into teeth, while the ultimate pinnæ become dentate pinnules. The upper portions of the pinnules, after the loss of their lobing, look somewhat like a small Cladophlebis. This species, while it is most abundant in the Baltimore strata, is found also in the beds of the Rappahannock horizon of Virginia. The specimen bears the number 5358 of the museum of the Woman's College of Baltimore.

VITIPHYLLUM MULTIFIDUM Fontaine.[a]

Pl. CXIX, Figs. 2–4.

Vitiphyllum multifidum was first described in Monograph XV from Belt and Covington streets, Baltimore. It is much the most common plant in the recent collections from Federal Hill, which contain no fewer

[a] See p. 553.

than 150 specimens of it, occurring in most of the collections. As in the case of the leaves which were the basis of the description given in Monograph XV, they are mostly fragmentary and detached. The texture of the leaves seems to have been, although rather thick, unfavorable for preservation. At least not a single one of the numerous specimens that have been found is an entire leaf. The figures of this species given in Monograph XV show that there is a considerable variation in the size of the leaves, the shape of the lobes, and in their number. It is possible that there is more than one species in the leaves assigned to this species, but the variations appear inconstant, and they graduate into one another in such a way as to make it impossible to separate them. Pl. CXIX, Fig. 2, gives a leaf unusually large. Figs. 3, 4 represent leaves of average size, which, taken together, may give a pretty good idea of their shape. The specimen shown in Fig. 2 occurs in collection No. 5 and is W. C., B., No. 5961. The two leaves represented in Figs. 3 and 4 are on the same side of one large slab, which is W. C., B., No. 6242. It occurs in collection No. 4, without date.

Ament of conifer (*b*).

In Monograph XV a number of aments of conifers are described which could not be connected with any species based upon foliage. These were designated by the letters of the alphabet, as ament of conifer (a), etc. The ament designated ament (b)[a] seems to be present in the collections from Covington and Clement streets. It is represented by a single detached form. It must, from this, have been very rare in the flora. The specimen occurs in collection No. 5 and is W. C., B., No. 5976.

AGE OF THE FEDERAL HILL BEDS.

The plants obtained from the horizon of the strata of Federal Hill show some features that make it difficult to determine satisfactorily their age by a comparison with those described in Monograph XV, from the Lower Potomac of Virginia. This will best be shown by an examination in some detail of the list of plants obtained at the Baltimore localities.

For the purpose of comparison with the Virginia plants, all those doubtfully determined and those coming from the Baltimore localities

[a] Monograph XV, p. 225, pl. cxxxvi, fig. 3.

only will be omitted. The plants that are available for this comparison are the following:

Acrostichopteris parvifolia, with 19 specimens.
Brachyphyllum crassicaule, with 3 specimens.
Cladophlebis alata (Pecopteris strictinervis type) with 1 specimen.
Cladophlebis Browniana, with 2 specimens.
Leptostrobus longifolius, with 2 specimens.
Menispermites tenuinervis, with 4 specimens.
Menispermites virginiensis, with 1 specimen.
Nageiopsis angustifolia, with 8 specimens.
Nageiopsis heterophylla, with 4 specimens.
Thyrsopteris Meekiana angustiloba, with 1 specimen.
Thyrsopteris pachyrachis, with 5 specimens.
Thyrsopteris rarinervis, with 1 specimen.
Ament of conifer (b), with 1 specimen.

Menispermites virginiensis, *M. tenuinervis*, and ament of conifer (b) are the only plants in this list that have not been found in the Rappahannock series or the lower portion of the Lower Potomac of Virginia. As only one specimen of the first of these occurs it can not have much importance in the flora and might be interpreted as an anticipation of a later flora, and not yet fully established, for it is more at home in the Aquia Creek horizon. But *Menispermites tenuinervis*, from the number (4) of its specimens, is of more importance. This is an important form in the collections from Fort Foote, which is on the Aquia Creek horizon, and it is abundant in the Mount Vernon group of beds. If, guided by the general difference in the flora, we divide the Lower Potomac into two horizons, the lower would contain the James River and Rappahannock series of Professor Ward, with essentially the same flora. The upper would embrace the Aquia Creek or Brooke beds and the Mount Vernon group, the latter being somewhat the older of the two. The upper member, as before stated, differs from the lower in having a decidedly smaller proportion of survivors of the Jurassic flora, few of the more archaic dicotyledons, and a larger proportion of dicotyledons of modern aspect. So far, then, as the evidence of *Menispermites tenuinervis* goes, the Baltimore beds would be placed on the Aquia Creek horizon. But even in this case, only four specimens being found in collections embracing hundreds, they

could not be taken as indicating that the plant was common in the flora. *Nageiopsis angustifolia, Thyrsopteris Meekiana angustiloba, T. rarinervis, Cladophlebis Browniana, Leptostrobus longifolius, Brachyphyllum crassicaule,* and *Cladophlebis alata,* in the Virginia beds, pass from the Rappahannock into the Aquia Creek series, all except the first being much more characteristic of the Rappahannock than of the Aquia Creek horizon. *Nageiopsis angustifolia* is probably more common in the upper than in the lower beds. But the small number of these species impairs their value as determiners of age. *Nageiopsis angustifolia* is the only one whose abundance entitles it to much weight, and it is almost as abundant in the lower as in the upper member. The plants that are confined to the Rappahannock series are these:

Acrostichopteris parvifolia.
Nageiopsis heterophylla.
Thyrsopteris pachyrachis.

Here we have the plants more abundantly represented in the Baltimore beds, and this is especially true of *Acrostichopteris parvifolia,* with 19 specimens. The genus Acrostichopteris is of more value for determining the age of these beds than any other of those named above. In the first place we may note that all the occurrences of the species of this genus, other than those on the horizon of the Baltimore beds, are confined to the Rappahannock portion of the Lower Potomac. The particular species now in question is found in the localities on James River mentioned in Monograph XV, rarely at the entrance to Trents Reach, and rather abundantly at the fishing hut above Dutch Gap Canal.

By far the most important plants of the Baltimore beds are not found in the Virginia Potomac, and can not help the comparison. It is a noteworthy fact that so many species occur in the Baltimore strata that are peculiar to them, and that some of these show so many specimens here while they are wholly wanting on other horizons. It might be taken to mean that the Baltimore horizon is wanting in Virginia and the District of Columbia, where also they are not found. It is more probable, however, that it is explained by the very local distribution of the elements of the Lower Potomac flora. This is indicated by the local distribution of many forms in the Virginia Potomac.

The species peculiar to the Baltimore beds are the following:

Acrostichopteris longipennis, with 57 specimens.
Celastrophyllum latifolium, with 11 specimens.
Celastrophyllum obovatum, with 17 specimens.
Proteæphyllum dentatum, with 15 specimens.
Vitiphyllum multifidum, with 150 specimens.
Vitiphyllum parvifolium, with 7 specimens.

Of less importance are the new species:

Adiantites parvifolius, with 1 specimen.
Plantaginopsis marylandica, with 5 specimens.

It should be noted, as indicating a Rappahannock age for the beds, that the only species of the genus Vitiphyllum found outside of the Maryland localities occurs in the Rappahannock beds at the locality Roadside near Potomac Run, in Virginia. It is very rare here. It is also noteworthy that the most characteristic plants of the Aquia Creek beds in Virginia and at Fort Foote, such as the different species of Sapindopsis, are wholly wanting. Sapindopsis is so abundant in the Aquia Creek beds that its absence is a strong indication that, where this occurs, the strata are not of Aquia Creek age. The peculiar species of Populus, Proteæphyllum, etc., so characteristic of the Mount Vernon strata, are also absent. This gives a presumption that the Baltimore strata are not of Mount Vernon age.

I was for a time of the opinion that these Baltimore beds are a peculiar phase of the Aquia Creek series. This conclusion was reached from the fact that they contain so many dicotyledons having an aspect different from that of the archaic Ficophyllums, Proteæphyllums, etc., of the Rappahannock, while these are mostly absent. Pointing to the same conclusion was also the fact that other characteristic types of the Rappahannock are wanting, or but feebly represented. The dicotyledons, although strongly represented, are still very peculiar and archaic, and the more modern forms of the Mount Vernon and Aquia Creek are wholly wanting. On the whole, it may be stated that the balance of evidence is strongly in favor of the Rappahannock age of the beds. When we take into consideration the character of the rock material, it may be concluded that they belong to the Arundel member of the subdivision made by the Maryland Survey.

FOSSIL PLANTS FROM UNION TUNNEL.

PINITES LEEI Fontaine n. sp.

Pl. CXIX, Figs. 6, 7.

A single specimen of an interesting cone was found in excavating the Union tunnel in Baltimore. It was found by the late Mr. John W. Lee, embedded in the clay through which the tunnel was being constructed. It was so well preserved that it was picked out practically entire from the embedding material, showing in a striking manner the preservative action of an air-tight and water-tight clay. This clay is given on the label as Arundel in age. The cone shows all the scales present and closed around the axis. It is somewhat distorted by pressure, owing to the creep of the inclosing clay or shale. The distortion has produced on one side of the cone a thinning of the cone scales at their tips. The latter (the tips), owing to the creep of the shale toward the top of the cone, are not much thicker than other portions of the scales. This was probably an effect produced on the underside of the cone. On the opposite side the cone is less compressed, and the creep or movement of the shale seems to have been in the opposite direction—that is, toward the base of the cone. The scales on this side expand at their tips into a triangular umbo that is elongated at right angles to the axis of the cone and is strongly striated. The precise shape of the umbo depends on the amount of compression and distortion of the scales. If the cone were seen only on the under side, it would agree pretty well with a cone of Abies, while on the upper side the cone scales would pass for those of Sequoia. The cylindrical form of the cone and the close appression of its thin scales make it probable that the plant is nearest to the Picea section of Pinus. It is 4 cm. long and 2 cm. wide. It is probably an unripe cone. Its specific name is from the name of its finder, Mr. Lee. Pl. CXIX, Fig. 6, gives the underside and Fig. 7 the upper side.

The specimen was lent by Mr. Lee to the Woman's College, and the label accompanying it bears the initials W. C., B., but no number.[a]

[a] But for the positive statement of Mr. Bibbins that the Union tunnel was cut through beds of Potomac clay and that this cone was actually found in such clay, so as to leave no doubt as to its age, I should hold decidedly to the opinion that the cone represents a comparatively modern type, such as some of the now living species of Picea or firs. Even as it is, I can not wholly divest my mind of the idea that it may have occurred

FOSSIL PLANTS FROM SPRINGFIELD.

[Pl. LXXX, No. 26.]

The plants now in question are designated on the labels accompanying them as coming from Springfield, and the formation yielding them is given as Patuxent. The rock material yielding the fossils is a reddish brown sandstone, which is highly ferruginous, with a cement of limonite. Although there is a considerable amount of this material, not many of the plant impressions can be determined, owing to the fact that it is not favorable for their preservation. The fragments of plants are much macerated and seem to have floated long in water. Most of the plant matter is in the form of decayed bits of stems that can not be determined. These specimens were collected by Mr. Bibbins in August, 1894, for the museum of the Woman's College of Baltimore, whose numbers are on the labels.

The following plants have been found at this locality:

Athrotaxopsis expansa Font.?	3 specimens.
Athrotaxopsis tenuicaulis Font	1 specimen.
Equisetum Lyellii Mant.?	2 specimens.
Sequoia subulata Heer?	2 specimens.
Thyrsopteris nervosa Font.?	1 specimen.

This list, as will be seen, is a very small one, and only one specimen, *Athrotaxopsis tenuicaulis*, is capable of positive determination.

These plants are not sufficient to determine the age of the strata containing them, but so far as their evidence goes, it indicates that it is that of the lowest portion of the Lower Potomac, the Rappahannock, and the James River series of Professor Ward.

FOSSIL PLANTS FROM STEMMERS RUN.

[Pl. LXXX, No. 41.]

Hengmehl's iron mine, Stemmers Run, furnishes one specimen which can not be determined.[a]

in some small pocket of Pleistocene (Columbia) clay, such as that which is sometimes found in excavating cellars, etc., in Washington, and which usually contains the remains of so-called cedar wood in a perfect state of preservation. Such a case occurred at the "Casino" on Connecticut avenue, and similar deposits have been found in the eastern part of the city, the Potomac clays immediately underlying the Columbia beds.—L. F. W.

[a] It is from this general region that the cycad, *Cycadeoidea Fisheræ*, described above (p. 470), was obtained.—L. F. W.

FOSSIL PLANTS FROM BROAD CREEK.

[Pl. LXXX, No. 2.]

The rock material from Broad Creek is a dark porous muck made up chiefly of comminuted vegetable matter. On the labels the age is given as Patuxent. The collection was made by Mr. Bibbins for the Maryland Geological Survey in September, 1896. The plants are very imperfectly preserved, from long exposure. The number of determinable specimens is small. The following species are found here:

Abietites angusticarpus Font.? ..... 1 specimen.
Cladophlebis Browniana (Dunk.) Sew.? ..... 1 specimen.
Cladophlebis distans Font. ..... 1 specimen.

These plants all come in the Virginia Potomac in the Rappahannock and James River series. They are insufficient to prove the age of the beds containing them, but their evidence, such as it is, indicates that the strata at Broad Creek are of the same age and hence agree with those of Springfield.

A specimen of indurated white grit rock, given on the label as coming from "Wanna's Broad Creek clay," "base of the Potomac," shows nothing determinable.

FOSSIL PLANTS FROM PLUM CREEK.

[Pl. LXXX, No. 16.]

A massive ferruginous sandstone from Plum Creek, Cecil County, Patapsco ? formation, gives some vegetable remains that are not determinable.

FOSSIL PLANTS FROM MUDDY CREEK.

[Pl. LXXX, No. 15.]

ARAUCARITES VIRGINICUS Fontaine.

Pl. CXIX, Fig. 8.

1889. *Araucarites virginicus* Font.: Potomac Flora (Monogr. U. S. Geol. Surv., Vol. XV), p. 263, pl. cxxxiv, fig. 7.

Muddy Creek, Cecil County, yields a single specimen. It is an imprint made by a portion of a cone that was once embedded in ash-gray shale but has since fallen out. It is imperfectly preserved and is probably a cone of *Araucarites virginicus*. As this fossil, in the Virginia Potomac,

is confined to the Rappahannock horizon, its presence denotes an Arundel or Rappahannock age for the beds containing it. This appears to have been somewhat smaller than the one figured in Monograph XV. It is given in Pl. CXIX, Fig. 8. It was collected by Mr. Bibbins for the Maryland Geological Survey in August, 1899, and bears the number 5312 of that survey.

FOSSIL PLANTS FROM LOCUST OR POPLAR POINT.

[Pl. LXXX, No. 10.]

Locust or Poplar Point has yielded to the collections five or six rock fragments with plant matter. The rock material is an ash-gray, rather arenaceous shale, stated on the labels to be Patapsco in age. This clay has a good many bits of carbonized vegetable matter which are not determinable. Two specimens, however, are small cones that are most probably cones of *Athrotaxopsis expansa*, but which can not be determined positively as such. The evidence from these is not sufficient to locate the horizon of the plants. This Athrotaxopsis is, in the Virginia localities, most characteristic of the Rappahannock horizon.

The material containing these impressions was collected by Mr. Bibbins in July, 1897, for the Maryland Geological Survey. It is all under one label marked M. G. S., No. 5316. A single specimen collected in August, 1899, and marked M. G. S., No. 5315, shows nothing determinable.

FOSSIL PLANTS FROM GRAYS HILL.

[Pl. LXXX, No. 6.]

A few plants are credited on the labels to Grays Hill, Cecil County, formation Patapsco, collected by Mr. Bibbins for the Maryland Geological Survey in August, 1899. The rock material is much like that from Vinegar Hill. The determinable fossils are 1 specimen of *Podozamites distantinervis* Font. and 2 of *Sphenolepidium Sternbergianum densifolium* Font. They probably belong to the former. The plants do not suffice positively to determine whether the Grays Hill strata correspond to the Rappahannock or to the Aquia Creek member of the Virginia Potomac.

GENERAL REMARKS AND CONCLUSIONS.

The localities described in the preceding pages are all that have furnished fossil plants from horizons below the Raritan. The size of the collections coming from the various localities can not be judged from the number of forms given as found at them, for when determinable forms exist no mention is made of the number of specimens that are not determinable. The proportion of these, in collections that have afforded a considerable number of identifiable species, varies much. For example, many specimens from the Arlington localities can not be determined, while hardly a rock fragment from Vinegar Hill or from Covington and Clement streets is without some identifiable imprint.

The study of the fossils in the collections of the Maryland Survey and the Woman's College of Baltimore makes it plain that the same flora existed in Maryland and Virginia in Lower Potomac times and that it underwent the same changes with the lapse of time. It appears that there is no important difference between the plants that existed in the times of the deposition of the Patuxent, Arundel, and Patapsco members. The flora is very poorly represented in the Patuxent, probably from the conditions of entombment and the unfitness of the rock to preserve plant remains. Fossil plants are much more abundant in the Arundel and Patapsco, but they give simply a continuation, and perhaps an amplification, of the Patuxent elements. An important change does not take place until the Raritan is reached. The plants show that nearly all the localities belong to the Rappahannock or James River member of the Potomac of Virginia. The Mount Vernon member is not shown. This, perhaps, was to be expected, for the Mount Vernon flora in Virginia seems to exist at but few spots, and to be preserved in local clay lenses only a few feet below the Aquia Creek group.

The Aquia Creek member of the Potomac seems to be generally absent from the Maryland localities whose fossil plants have been described in this paper. The plants collected by Professor Ward at Fort Foote, on the Potomac River below Washington, show that it is found there.

The comparison of the Maryland species with those of Virginia shows the unexpected fact that the large Maryland collections add very few new forms to the Lower Potomac flora, as made known in Monograph XV.

The Potomac of Maryland differs from that of Virginia in the apparent absence of the Mount Vernon member and in the apparent confinement of the Aquia Creek to the Fort Foote locality. It differs in another respect—the absence in Virginia of the Raritan, which is so conspicuous in Maryland. It has been stated in preceding pages of this paper that in Virginia the Lower Potomac has been divided by Professor Ward into the following members, mentioned in ascending order: (1) James River, (2) Rappahannock, (3) Mount Vernon, (4) Aquia Creek. The Rappahannock is identical with the beds I have named Fredericksburg, and the Aquia Creek with the Brooke beds as given in Monograph XV. The Maryland Geological Survey divides the formation, in ascending order, into (1) Patuxent, (2) Arundel, (3) Patapsco, and (4) Raritan. In neither of these divisions is there any question of a division of the formation into an upper and a lower member, while I have constantly referred to the Potomac of Virginia as Lower Potomac. It is, then, necessary to explain what is meant by Lower Potomac. In my opinion, the change in the character of the plants, in passing from the base to the summit of the heterogeneous mass of nonmarine deposits, called by most writers Potomac, necessitates a subdivision of it into a lower and an upper member, if the Raritan is regarded as Potomac. Other subdivisions may be made that are based on changes in lithological character or on want of continuity, etc., but the more the plants are studied the more clearly it appears that there is only one great break in the continuity of the flora, and that is in the passing from the underlying beds into those called Raritan or Amboy clays. Judging from the plants, the Raritan member forms the Upper Potomac, if it is Potomac, while all below is included in the Lower Potomac.

The main difference between the Potomac of Virginia and that of Maryland lies in the fact that the Raritan is absent in the former, while it is in force in the latter State.

It is not contended that there are not considerable changes in the flora of the Lower Potomac in passing to higher beds. This change is a gradual one, caused by the diminution of old types and the increase and introduction of more modern ones, but there is no wholesale change, and the flora shows essential continuity. Some of the changes have already been indicated in pointing out the differences between the Rappahannock or James River member and the higher Mount Vernon and

Aquia Creek groups. While many of the old types, much diminished in numbers, pass up into the Mount Vernon and Aquia Creek horizons, in number of individuals they are to some extent subordinate to more modern types. The case is very different in passing up into the Raritan or Amboy clays. Here there is a wholesale change. Few, if any, of the older types persist. Even those more modern types that were introduced in the Mount Vernon and Aquia Creek groups disappear. A great number of wholly new plants, more recent in character than were the most modern of the Aquia Creek strata, appear, and dicotyledons overwhelmingly predominate. In a word, in passing into the Raritan strata we find the flora wholly changed. This being the case, the question may be asked, Why give the name Potomac to this group? It has, it is true, in common with the underlying strata, a nonmarine or estuarine character in the deposits, and this seems to be the reason for making it a member of the Potomac. Professor Marsh thought that he had, from the vertebrate fauna found in the Arundel member, proved that its age is Jurassic. He, with most writers on the subject, included the Raritan in the Potomac, but, unlike others, he went further, and maintained that the whole formation is Jurassic. It might with reason be maintained that Professor Marsh's conclusion as to the age of the whole formation is the logical one. If the continuity of the formation is sufficient to make the Raritan a member of the Potomac, and if the age of the lower portion of the Potomac is Jurassic, it might be claimed that the Raritan must be Jurassic. Hardly anyone would now maintain such an age for it.

As indicated above, Professor Marsh maintained that the whole of the Potomac is Jurassic in age. This was based on the evidence of vertebrate fossils found in the Arundel of Maryland. So far as I am informed, no one is disposed to go as far as Professor Marsh for the whole formation, but some agree with him in regarding at least the lower portion of the Potomac as Jurassic, and Professor Clark and Mr. Bibbins regard the age of the Patuxent and Arundel as possibly Jurassic. The question of the Jurassic or Lower Cretaceous age of the Lower Potomac hinges upon the position of the Wealden formation.

After a study of the Lower Potomac plants described in Monograph XV, I expressed the opinion that they indicated a Lower Cretaceous

age for the formation,[a] agreeing with the Neocomian. This conclusion was based on the strong affinity of its flora with that of the Wealden. It was assumed that the view generally held as to the position of the Wealden is correct—that is, that it is the nonmarine equivalent of the Neocomian. There has been no evidence sufficient to cause a change of this opinion, but, on the contrary, a good many facts have come to light that confirm its correctness. That is, there is additional reason to think that the Lower Potomac has a flora that is essentially Wealden, and also that the Wealden is Lower Cretaceous rather than Jurassic.

Professor Marsh held that the Wealden is Jurassic. If that is correct the Lower Potomac is Jurassic. Since Monograph XV was written many discoveries of a flora essentially Wealden or Lower Potomac in character have been made, which indicate that it existed at a time when the marine Jurassic conditions, which had previously prevailed, were followed by those under which nonmarine sediments were laid down. These varied a good deal. Sometimes the sea was advancing over the land, and shallow water, estuarine, and other similar sediments accumulated. In other cases lakes and marshes were formed, sometimes with the accumulation of vegetable matter for the formation of coal beds. In these deposits the Lower Potomac flora is found. This flora is a transition one from the typical Jurassic of Oolitic type, now known to exist in Oregon, to the typical Cretaceous of the Dakota and later formations. The localities furnishing fossils belonging to this flora show that it had a surprisingly wide distribution. It has been found as far north as the Kootanie in British Columbia and as far south as Tlaxiaco in Mexico. On the eastern side of the continent this fossil flora exists in the eastern portions of Virginia and Maryland. On the western side it is found in the Shasta group of California. The fact that this flora is found in strata which are often superposed on Jurassic beds with want of conformity, and which by their character show that important changes had taken place since the Jurassic conditions prevailed, and the farther fact that the flora is transitional, make it a priori probable that it is Lower Cretaceous rather than Jurassic. But we are not without direct evidence that this flora is Neocomian or Lower Cretaceous. This will be given farther on.

[a] Monograph XV, p. 348.

As an instance of the superposition of beds of nonmarine type containing the Potomac flora on marine Jurassic beds the Hay Creek strata of Wyoming may be mentioned. In the Hay Creek region of Wyoming there are fresh-water and marsh deposits that contain a well-marked Lower Potomac flora. These rest unconformably on Jurassic marine strata. In the Black Hills, also, we find nonmarine deposits containing the Lower Potomac flora resting on marine Jurassic beds.

We have direct evidence of the Neocomian age of the Lower Potomac flora in the following cases:

The Glen Rose beds of the Trinity group in Texas have yielded a number of fossil plants belonging to the Lower Potomac flora. These fossils occur in a lens of fine sediment, in a chalky calcareous mass that abounds in marine Neocomian invertebrates. Professor Marsh, from the comparison of the Atlantosaurus or Como beds of Colorado and Wyoming and their contained vertebrate fauna with the Lower Potomac of Maryland, was led to think that they are both of Wealden age. It is interesting to find that Mr. Willis T. Lee has traced these deposits, bearing the name "Morrison formation," southward until they nearly make a junction with the Trinity beds of Texas, described by R. T. Hill. He makes this statement:[a]

> According to Mr. Hill's section the Lower Cretaceous, consisting of the Trinity, Fredericksburg, and Washita, lies between the Red Beds and the Dakota. If Mr. Hill's section represents correctly the age of the formations in the Canadian Valley, then the shales and possibly the Exeter sandstone must be of Lower Cretaceous age. But the shales, as I have already shown, are probably the same as the dinosaur-bearing shales of the Purgatory. There is some probability therefore that the Morrison formation may be identical with some part of the Lower Cretaceous of the Texas region.

In the Shasta group of California the Lower Potomac is well represented and here a Neocomian invertebrate fauna accompanies it.

Dr. J. Felix found in central Mexico, in the Cerro de la Virgen, near Tlaxiaco, fossil plants of the Lower Potomac in a formation containing numerous animal fossils, which, in the opinion of Doctor Felix, fully prove the Neocomian age of the beds. Doctor Felix sent a small collection of the plants to Doctor Nathorst for determination.[b] The

[a] Journ. Geol., Vol. X, No. I, 1902, p. 57.

[b] Nathorst, in Felix & Lenk, Uebersicht über die geologischen Verhältnisse des mexicanischen Staates Oaxaco, Beiträge zur Geologie und Paläontologie der Republik Mexico, von J. Felix und H. Lenk, II. Theil, I. Heft, Leipzig, 1893, pp. 51–54.

latter identified three species. Two of them, *Sequoia ambigua* Heer and *S. Reichenbachi* (Gein.) Heer, are important fossils in the Lower Potomac of Virginia. The third is identical with a fossil described by me from the Glen Rose beds of the Trinity of Texas, with the name *Pagiophyllum aubium*.[a] This latter plant Doctor Nathorst named *Pseudofrenelopsis Felixi*, and in describing it he made some errors which, as they may lead to further errors and confusion, are noticed below.

These facts seem to indicate that a Neocomian or Lower Cretaceous age may be claimed with a good deal of confidence for the Lower Potomac flora.

So far as I am informed, the only evidence claimed to oppose the conclusion that these beds are Lower Cretaceous is that presented by Professor Marsh, which was derived from an examination of the vertebrate fauna of the Arundel group and the Como beds. This, however, simply goes to indicate the Wealden age of the strata.

When Doctor Nathorst made his determination of the Mexican plants for Doctor Felix he had not seen the paper on the Texas Glen Rose fossils prepared by me, and when his paper was prepared Doctor Nathorst's article had not been read by him. The result was that the same species was described under two different names. However, Doctor Nathorst had before him my description of *Frenelopsis parceramosa* given in Monograph XV. From certain similarities in the Virginia and Mexican fossil Doctor Nathorst concluded that they are the same. From the study of the Mexican plant he decided that the Virginia fossil had been incorrectly diagnosed. Hence he formed a new genus, which he calls Pseudofrenelopsis. Had Doctor Nathorst possessed specimens of *Frenelopsis parceramosa* he would never have fallen into this error. The plants are quite different and probably are not nearly allied. The Texas plant, which is that described by Doctor Nathorst, does not have jointed branches. Doctor Nathorst assumes that I incorrectly diagnosed *Frenelopsis parceramosa* as having jointed twigs. There is not the shadow of a doubt that it has. *F. parceramosa* has its branches conspicuously constricted at the joints, and the latter are so marked that the branches break up into small fragments by a separation at the joints. Hence it is difficult to get a twig of any considerable length.

[a] Fontaine, Notes on some fossil plants from the Trinity division of the Comanche series of Texas: Proc. U. S. Nat. Mus., Vol. XVI, 1893, pp. 271–273, pl. xxxix, figs. 2–11.

A stratum at Dutch Gap in Virginia, where this plant was first found, is full of multitudes of small fragments of it, each representing one or two joints. I was in great doubt as to the true place of the fossil he named *Pagiophyllum dubium*, and with much hesitation placed it provisionally in the genus Pagiophyllum. He did not think the amount of material on hand justified the formation of a new genus. As this plant probably is not a Pagiophyllum, it may well continue to bear the name given it by Doctor Nathorst, and the name *Pagiophyllum dubium* should be dropped. It should not, however, be identified with *Frenelopsis parceramosa*. A plant nearly allied to the latter, but probably a different species, occurs in the Glen Rose strata.

CORRELATION OF THE POTOMAC FORMATION IN VIRGINIA AND MARYLAND.

The above report of Professor Fontaine on the fossil plants collected in the Potomac formation since the appearance in 1889 of his Potomac or Younger Mesozoic Flora furnishes a much better basis for correlating the Maryland and Virginia beds of that formation than that which existed at that time or at the later date (1895) when my memoir on the Potomac formation appeared. In order, however, still more fully to appreciate the advance thus made in our knowledge of the flora in the two States, and to furnish a condensed view of the results, I have prepared the following table of distribution of the species enumerated in the report:

Table of distribution

Number.	Species.	Localities in Virginia.														
		James River.	Alum Rock.	72d Milepost.	Near 72d Milepost.	Bank near Brooke.	Cockpit Point.	Woodbridge.	Lorton Station.	Colchester road.	White House Bluff beds.	Mount Vernon beds.	Hell Hole.	Mouth of Hell Hole.	Chinkapin Hollow.	
															Lower bed.	Upper bed.
1	Abietites angusticarpus Font															
2	Abietites ellipticus Font															
3	Abietites macrocarpus Font															
4	Abietites marylandicus Font. n. sp															
5	Acaciæphyllum microphyllum Font								3							
6	Acrostichopteris longipennis Font															
7	Acrostichopteris parvifolia Font															
8	Adiantites parvifolius Font. n. sp															
9	Angiopteridium strictinerve Font														1	
10	Antholithes Gaudium-Rosæ Ward											3				
11	Aralia ? vernonensis Font. n. sp											1				
12	Araucarites aquiensis Font										1					1?
13	Araucarites virginicus Font															
14	Aristolochiæphyllum ? cellulare Ward n. sp											2				
15	Aristolochiæphyllum crassinerve Font				8								2			
16	Athrotaxopsis expansa Font												2			
17	Athrotaxopsis grandis Font															
18	Athrotaxopsis tenuicaulis Font															12
19	Baieropsis adiantifolia Font														1	
20	Baieropsis denticulata angustifolia Font											2				
21	Baieropsis foliosa Font			3	1						1		9	4?		
22	Baieropsis longifolia Font												1			
23	Baieropsis pluripartita Font	1		16		6							3			
24	Brachyphyllum crassicaule Font															
25	Brachyphyllum parceramosum Font															
26	Carpolithus brookensis Font										2					
27	Carpolithus virginiensis Font		1										1			
28	Casuarina Covillei Ward											1				
29	Celastrophyllum acutidens Font															
30	Celastrophyllum albædomus Ward n. sp										1					
31	Celastrophyllum Brittonianum Hollick											1				
32	Celastrophyllum brookense Font													2?		
33	Celastrophyllum Hunteri Ward											2				
34	Celastrophyllum latifolium Font															
35	Celastrophyllum ? marylandicum Font. n. sp															
36	Celastrophyllum obovatum Font													1?		
37	Celastrophyllum ? saliciforme Ward n. sp											1				
38	Cephalotaxopsis ramosa Font															
39	Cladophlebis acuta Font															
40	Cladophlebis acuta angustifolia Font															
41	Cladophlebis alata Font		1												3	
42	Cladophlebis Browniana (Dunk.) Sew														1	
43	Cladophlebis constricta Font													2?		
44	Cladophlebis crenata Font															
45	Cladophlebis distans Font															
46	Cladophlebis falcata Font														3	
47	Cladophlebis inæquiloba Font														3	
48	Cladophlebis parva Font														5	

of Potomac plants.

Localities in the District of Columbia.						Localities in Maryland.																																Whole number of specimens of each species.
Sixteenth street.	New reservoir.	Terra Cotta.	Ivy City.	Langdon.	Queens Chapel road.	Rosiers Bluff.	Riverdale.	Bewley estate.	Muirkirk.	Contee.	Arlington.	Hanover.	Howard Brown estate.	Reynolds's ore pit.	Germant's iron mine.	Hobbs's iron mine.	Tip Top.	Vinegar Hill.	Soper Hall.	Lansdowne.	Federal Hill.	Union Tunnel.	Springfield.	Broad Creek.	Muddy Creek.	Locust or Poplar Point.	Grays Hill.										
						1					3							3		1				1?														9
																		10																				10
																		18																				18
																		2																				2
																																						3
																					57																	57
																					19																	19
																					1																	1
																																						1
																																						3
																																						1
						10																																12
																									1													1
																																						2
						2																																12
				52			4		98	1?	57		3?			4?	4?	1?	3?				3?			2?											234
																	1?																					1
11				15							1						1?						1															41
						1?					1?																											3
																																						2
						5																																23
	1																																					2
																																						26
						4															3																	7
	3?										29																											32
																																						2
																																						2
																																						1
						31																																31
																																						1
																																						1
																																						2
																																						2
																					12																	12
																					1																	1
																		1			17																	19
																																						1
											3?							1?																					4
											400																												400
											115																												115
											2		1?								1																	8
	1										2?	1						1?			2			1?														9
						1?												3																					6
																		2																					2
																								1															1
																		2																					5
																																						3
						1					1?																													7

Table of distribution

Number.	Species.	Localities in Virginia.															
		James River.	Ahun Rock.	72d Milepost.	Near 72d Milepost.	Bank near Brooke.	Cockpit Point.	Woodbridge.	Lorton Station.	Colchester road.	White House Bluff beds.	Mount Vernon beds.	Hell Hole.	Mouth of Hell Hole.	Chinkapin Hollow. Lower bed.	Chinkapin Hollow. Upper bed.
49	Cladophlebis rotundata Font.											1			1	
50	Cladophlebis sphenopteroides Font.															
51	Cladophlebis Ungeri (Dunk.) Ward.														1	
52	Cladophlebis virginiensis Font.														2	
53	Ctenis imbricata Font.														3	
54	Ctenopteris angustifolia Font.														4	
55	Ctenopteris insignis Font.															
56	Cycadeospermum acutum Font.		1													
57	Cycadeospermum ellipticum Font.															
58	Cycadeospermum obovatum Font.							1								
59	Cycadeospermum rotundatum Font.															
60	Dioonites Buchianus (Ett.) Born.	3					4		9							
61	Dioonites Buchianus abietinus (Göpp.) Ward.								1							
62	Dryopteris angustipinnata (Font.) Kn.															
63	Dryopteris fredericksburgensis (Font.) Kn.														5	
64	Dryopteris heterophylla (Font.) Kn.						3									
65	Dryopteris parvifolia (Font.) Kn.								1							
66	Dryopteris virginica (Font.) Kn.											4				
67	Encephalartopsis nervosa Font.														1	
68	Ephedrites ? vernonensis Font. n. sp.											1				
69	Equisetum Lyellii Mant.															1?
70	Equisetum marylandicum Font.															
71	Equisetum virginicum Font.						2?		1?							
72	Eucalyptus rosieriana Ward n. sp.															
73	Feistmantelia virginica Font. n. sp.						4									
74	Ficophyllum crassinerve Font.											1?				
75	Ficophyllum eucalyptoides Font.										3					
76	Ficophyllum tenuinerve Font.												6?		3	
77	Ficus myricoides Hollick.															
78	Frenelopsis parceramosa Font.															
79	Frenelopsis ramosissima Font.												1?		7	
80	Ginkgo ? acetaria Ward n. sp.															
81	Glyptostrobus brookensis (Font.) Ward.				1		2		3		13	9				
82	Glyptostrobus brookensis angustifolius (Font.) Kn.										5					
83	Glyptostrobus expansus Font. n. comb.															
84	Glyptostrobus ramosus Font. n. comb.										1					
85	Leptostrobus foliosus Font.					1										
86	Leptostrobus longifolius Font.				1	4						3	1			
87	Leptostrobus ? ovalis Ward nom. nov.															1
88	Menispermites tenuinervis Font.											31				
89	Menispermites virginiensis Font.					3						27	3?			
90	Myrica brookensis Font.														2	
91	Nageiopsis angustifolia Font.											1				
92	Nageiopsis heterophylla Font.						1									
93	Nageiopsis longifolia Font.						1					1?			4	
94	Nageiopsis microphylla Font.						4									
95	Nageiopsis obtusifolia Font.						1									
96	Nageiopsis recurvata Font.															

of Potomac plants—Continued.

Localities in the District of Columbia.						Localities in Maryland.																										
Sixteenth street.	New reservoir.	Terra Cotta.	Ivy City.	Langdon.	Queens Chapel road.	Rosiers Bluff.	Riverdale.	Bewley estate.	Muirkirk.	Contee.	Arlington.	Hanover.	Howard Brown estate.	Reynolds's ore pit.	German's iron mine.	Hobbs's iron mine.	Tip Top.	Vinegar Hill.	Soper Hall.	Lansdowne.	Federal Hill.	Union Tunnel.	Springfield.	Broad Creek.	Muddy Creek.	Locust or Poplar Point.	Grays Hill.	Whole number of specimens of each species.
			1?																									2
											1?																	1
																												2
																												2
																												3
					2?																							4
									1?																			2
				2																								2
				1		4				1					1?													7
	1							1?			2?																	1
																												20
											13	22	7					1?										1
											1							1										43
																		8										7
											70																	11
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	19																				1?							20
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				37																								65
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											2																	2
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						2												26			2							39
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						2?		1?													1							37
																												2
1						6															8							16
				1?														1			4							7
						8												25			2?							41
																												4
																												1
																		1?										1

Table of distribution

Number.	Species.	Localities in Virginia.													
		James River.	Alum Rock.	72d Milepost.	Near 72d Milepost.	Bank near Brooke.	Cockpit Point.	Woodbridge.	Lorton Station.	Colchester road.	White House Bluff beds.	Mount Vernon beds.	Hell Hole.	Mouth of Hell Hole.	Chinkapin Hollow. Lower bed.	Chinkapin Hollow. Upper bed.
97	Nageiopsis zamioides Font														4	
98	Onychiopsis psilotoides (Stokes and Webb) Ward												1			
99	Osmunda dicksonioides Font															
100	Pecopterius brevipennis Font														1?	
101	Pecopteris constricta Font															
102	Pecopteris virginiensis Font		3													
103	Pinites Leei Font. n. sp															
104	Pinus Nordenskiöldi Heer															2?
105	Pinus schista Ward n. sp															
106	Pinus vernonensis Ward n. sp											3				
107	Plantaginopsis marylandica Font. n. sp															
108	Platypterygium densinerve Font															
109	Podozamites distantinervis Font	1?														
110	Podozamites pediceliatus Font															
111	Populophyllum menispermoides Ward n. sp											24				
112	Populophyllum minutum Ward n. sp											1				
113	Populus auriculata Ward											9				
114	Populus potomacensis Ward											22				
115	Potamogetophyllum vernonense Font. n. sp											1				
116	Proteæphyllum dentatum Font															
117	Proteæphyllum oblongifolium Font															
118	Proteæphyllum ovatum Font														1	
119	Proteæphyllum reniforme Font											20				
120	Proteæphyllum Uhleri Font. n. sp															
121	Quercophyllum chinkapinense Ward n. sp														14	
122	Quercophyllum tenuinerve Font															
123	Rogersia angustifolia Font											4			3	
124	Rogersia angustifolia parva Font n. v															
125	Rogersia longifolia Font														4	
126	Sagittaria Victor-Masoni Ward											1				
127	Saliciphyllum ellipticum Font															
128	Sapindopsis brevifolia Font			5		2										
129	Sapindopsis elliptica Font															
130	Sapindopsis magnifolia Font			1	1	1					3					
131	Sapindopsis tenuinervis Font										1					
132	Sapindopsis variabilis Font			10		2					28					
133	Sassafras bilobatum Font												1?			
134	Scleropteris elliptica Font														2	
135	Scleropteris vernonensis Ward											15				
136	Scleropteris virginica Font						1?									
137	Selaginella marylandica Font n. sp															
138	Sequoia ambigua Heer															
139	Sequoia cycadopsis Font										1					
140	Sequoia ? inferna Ward, nom. nov												2			
141	Sequoia Reichenbachi (Gein.) Heer															
142	Sequoia subulata Heer								3							
143	Sphenolepidium dentifolium Font						21									

of Potomac plants—Continued.

Localities in the District of Columbia.						Localities in Maryland.																									Whole number of specimens of each species.
Sixteenth street.	New reservoir.	Terra Cotta.	Ivy City.	Langdon.	Queens Chapel road.	Rosiers Bluff.	Riverdale.	Bewley estate.	Muirkirk.	Contee.	Arlington.	Hanover.	Howard Brown estate.	Reynolds's ore pit.	German's iron mine.	Hobbs's iron mine.	Tip Top.	Vinegar Hill.	Soper Hall.	Lansdowne.	Federal Hill.	Union Tunnel.	Springfield.	Broad Creek.	Muddy Creek.	Locust or Poplar Point.	Grays Hill.				
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Table of distribution

Number.	Species.	Localities in Virginia.														
		James River.	Alum Rock.	72d Milepost.	Near 72d Milepost.	Bank near Brooke.	Cockpit Point.	Woodbridge.	Lorton Station.	Colchester road.	White House Bluff beds.	Mount Vernon beds.	Hell Hole	Mouth of Hell Hole	Chinkapin Hollow.	
															Lower bed.	Upper bed.
144	Sphenolepidium Kurrianum (Dunk.) Heer						2?				1					
145	Sphenolepidium pachyphyllum Font								3							
146	Sphenolepidium parceramosum Font						1?									
147	Sphenolepidium Sternbergianum densifolium Font		1		1		1		2		3	6	19	4	6	49
148	Spenolepidium virginicum Font				1		1									
149	Sphenopteris grevillioides Heer											7				
150	Sphenopteris latiloba Font	1										1			2?	
151	Sterculia elegans Font											1?				
152	Thinnfeldia marylandica Font. n. sp															
153	Thinnfeldia variabilis Font											2				
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155	Thyrsopteris bella Font											2			1	
156	Thyrsopteris crassinervis Font														9	
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162	Thyrsopteris Meekiana Font															
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165	Thyrsopteris pachyrachis Font									8?						
166	Thyrsopteris pinnatifida Font														1?	
167	Thyrsopteris rarinervis Font						1?					6				1
168	Vitiphyllum multifidum Font															
169	Vitiphyllum parvifolium Font															
170	Williamsonia ? Bibbinsi Ward n. sp															
171	Williamsonia ? gallinacea Ward n. sp						1									
172	Zamia Washingtoniana Ward											11				
173	Zamiopsis insignis Font														17	
174	Zamites tenuinervis Font	1?							1							
175	Ament of a conifer (b) Font															
176	Ament of a dicotyledon ? Font															1
	Whole number of specimens from each locality	7	7	32	16	20	55	1	27	8	64	230	57	9	141	69

of Potomac plants—Continued.

| Localities in the District of Columbia. | | | | | | | | Localities in Maryland. | | | | | | | |

ANALYSIS OF THE TABLE.

It will be seen by this table that the whole number of species and varieties or plant forms which have been collected since the appearance of Professor Fontaine's monograph, and which he has treated in the above paper, is 176. As regards their diagnostic value in determining age and correlating the beds, he gives great weight to their relative abundance, and in preparing his report he took pains in most cases to count the specimens and give the exact number represented for each species. But where there were many specimens of one species he contented himself by so stating, without an exact count. After completing and submitting his report he shipped the entire collection to Washington. In editing his report for this paper I found it essential to consult the material constantly in order to make the history of the numerous collections complete and to indicate the exact source, proprietorship, and destination of every specimen, duplicates as well as figured types. This required me to arrange the specimens primarily by localities and then by species from each locality. Having done this it was comparatively easy to make an exact count of all the specimens of each species from each locality. As every determinable specimen was labeled both for the locality and for the species, this could readily be done, although, on account of the size of the aggregate collections, the task was laborious and required much time. In most cases the counting amounted simply to a verification of Professor Fontaine's manuscript, but in a number of cases, as might naturally be expected, the two counts differed. In all such cases I have used my own final count instead of his. The discrepancies were sometimes found to be due to the accidental mixing of specimens from different localities where the material was very similar, as, for example, that of Langdon with that of Tip Top, where one of the figured types was involved.

In making the count I extended it to all the species, no matter how numerous the specimens, even including *Cladophlebis acuta* from the Arlington beds with exactly 400 specimens. These exact results are substituted in the descriptions of the localities for the general statements which Professor Fontaine regarded as sufficient.

The table of distribution now under consideration differs from the usual form by taking account of the number of specimens as well as the mere fact of their occurrence at the several localities. Where, from

the meager data furnished by the specimens, the identity of the species is questioned, this is also indicated by an interrogation point opposite the number in the appropriate column and line of the table. As most of these are probably correct, I have thought best to treat them so in the analysis of the table, since the few cases in which they may be incorrect could not seriously affect the general results.

It thus appears that the 176 species are represented by 2,882 specimens, or a mean of a little over 16 specimens to each species. This of course is mainly due to a few species that are abundantly represented, though 47 species occur in only a single specimen. A still larger number have only two or three specimens. Still, 38 species are represented by 16 specimens or more, and a large number range from 10 to 25 specimens. The most abundant species are:

Cladophlebis acuta, with 400 specimens.
Athrotaxopsis expansa, with 234 specimens.
Sphenolepidium Sternbergianum densifolium, with 186 specimens.
Thyrsopteris rarinervis, with 152 specimens.
Vitiphyllum multifidum, with 151 specimens.
Sapindopsis variabilis, with 132 specimens.
Cladophlebis acuta angustifolia, with 115 specimens.

All the rest have fewer than 100 specimens, but *Dryopteris parvifolia* has 71, *Glyptostrobus* (*Taxodium*) *brookensis* 65, and *Acrostichopteris longipennis* 57, while eleven others have between 30 and 50 specimens.

The collections were made at 42 localities, but the number of both species and specimens from the different localities differs even more widely than does the number of specimens of the different species. The localities yielding the largest number of specimens are: Arlington, with 748; Federal Hill, with 324; Langdon, with 303; Rosiers Bluff, with 279; the Mount Vernon beds, with 230; Chinkapin Hollow, with 210; Vinegar Hill, with 129; Muirkirk, with 99; the new reservoir, with 97; White House Bluff, with 64; Hell Hole, with 57; and Cockpit Point, with 55. The rest all yielded fewer than 50 specimens each, and 8 localities are represented by a single specimen each.

Of the localities in Virginia besides those representing the Mount Vernon chocolate clays, the following have been discovered since the appearance of Professor Fontaine's monograph: Alum Rock, the bed at the north end of the 72d Milepost cut, Cockpit Point, Woodbridge, the

Colchester road, all but one of the Brooke localities in the White House Bluff, Hell Hole, Mouth of Hell Hole, and Chinkapin Hollow. None of the localities in the District of Columbia were known to Professor Fontaine at the date of the publication of his monograph, and of those in Maryland he was acquainted only with that of Federal Hill—(this does not include the cycads treated by him).

As clearly shown in the treatment of these localities, the beds at Alum Rock, Cockpit Point, Woodbridge, the Colchester road, and Chinkapin Hollow are on the horizon of the Rappahannock series, the two first named being actually in the typical Rappahannock freestone. Those at the 72d Milepost cut, at the White House Bluff, including the ones above Doag Creek overlying the Mount Vernon clays, and those at Hell Hole and the mouth of Hell Hole, are all on the horizon of the Brooke or Aquia Creek beds. Professor Fontaine's doubts regarding the Hell Hole material are quickly dispelled by a casual comparison of it with the chocolate clay of the Mount Vernon beds, while, as the table shows, the species are mostly those of the Brooke beds and not of the Mount Vernon beds. The testimony of the species, however, must be admitted to be somewhat conflicting or unsatisfactory, those best represented having a wide range. The Rosiers Bluff locality also certainly represents the Brooke series, most of the species being the same as those found in Virginia on that horizon. This bluff seems to be a simple extension of the White House Bluff across the Potomac, but lying, as it does, somewhat farther coastward in the formation, the underlying Mount Vernon clays and Rappahannock freestone beds of the Virginia shore are here below the level of the river. This, however, as Professor Fontaine now thinks, is the only plant-bearing locality on this horizon known on the left bank of the Potomac.

It remains to consider the other localities in Maryland, and for this discussion I shall treat those of the District of Columbia as belonging to the same general group as all the beds across the State of Maryland. There is no essential difference. It is in the correlation of these Maryland beds with those of Virginia that the chief interest of this paper centers. As shown in the historical part, Professor Clark and Mr. Bibbins, influenced, as they admit, by the views entertained by Professor Marsh, regard their Patuxent and Arundel formations as lower than any in Virginia, and as probably Jurassic. I have discussed this point as fully as is necessary,

and there is nothing left but to examine the evidence of the fossil plants which is marshaled in Professor Fontaine's report on the collections that these authors have themselves chiefly made. It is scarcely necessary to say that the comparison can not be confined to the data of this table alone, for the collections made from the Virginia beds since the appearance of Monograph XV are too small. The comparisons must be made with the entire Potomac flora of Virginia, published and unpublished. The collections from the Maryland localities may be regarded as fairly representative. Those from Arlington, Langdon, Vinegar Hill, Federal Hill, and the new reservoir are quite as full as those from many of the original Virginia localities.

Of the 176 species of the table 100 occur in the beds of the District of Columbia or of Maryland other than Rosiers Bluff, the other 76 being confined to Virginia localities and to Rosiers Bluff. We have therefore at present to do only with the 100 species. Of these, 76 are also found in the Rappahannock beds of Virginia. To make up the other 24 we have 12 new species, 9 that were previously known only from Federal Hill and 3 that were formerly confined to the Brooke horizon in Virginia. Of the new species and those that have never been found in Virginia I shall speak later on. Two species, *Glyptostrobus* (*Taxodium*) *brookensis* and *Sphenolepidium virginicum*, which were not known to occur in the Rappahannock beds of Virginia at the date of the appearance of Monograph XV, have now been found there, the first at Cockpit Point and Lorton and the second at Cockpit Point. *Glyptostrobus brookensis* is also abundant in the Mount Vernon beds. The three species or forms that were formerly confined to the Brooke beds of Virginia are (1) *Glyptostrobus ramosus*?, now found in the dump of the mines at Hanover, (2) *Menispermites virginiensis*, found at the Bewley estate and Federal Hill and also common in the Mount Vernon beds, and (3) the ament of a conifer (*b*), rediscovered at Federal Hill. Their diagnostic value can not be said to be great.

It thus appears that practically all except the new species are found in the Rappahannock and Mount Vernon beds of Virginia. Their occurrence in the Brooke beds also only serves to give them a somewhat more modern aspect. The flora of the Maryland beds referred to the Patuxent, Arundel, and Patapsco formations of Clark and Bibbins is therefore practically identical with that of the James River and Rappahannock

beds of Virginia. It contains absolutely no Jurassic or Older Mesozoic species.

The importance of the dicotyledons in any flora justifies a glance at the table from this special point of view. The total number of dicotyledons enumerated in the table is 48, of which 13 are new species. The following 17 species occur in the District of Columbia and Maryland exclusive of Rosiers Bluff:

Celastrophyllum latifolium.
Celastrophyllum ? marylandicum.
Celastrophyllum obovatum.
Ficophyllum tenuinerve?
Menispermites tenuinervis.
Menispermites virginiensis.
Plantaginopsis marylandica.
Proteæphyllum dentatum.
Proteæphyllum oblongifolium.
Proteæphyllum Uhleri.
Quercophyllum tenuinerve?
Rogersia angustifolia?
Rogersia angustifolia parva.
Rogersia longifolia.
Saliciphyllum ellipticum.
Vitiphyllum multifidum.
Vitiphyllum parvifolium.

Nine of these are found only at the Federal Hill locality and that of Vinegar Hill, and this fact must be admitted to argue strongly for the somewhat higher position of these beds than that of the others in Maryland exclusive of Rosiers Bluff. For my own part, notwithstanding Professor Fontaine's reasoning, I am disposed to regard them as intermediate between the Rappahannock and Brooke horizons, corresponding somewhat to the position of the Mount Vernon beds, although for some unknown reason there is scarcely any resemblance between the Mount Vernon and Federal Hill floras except that well-defined dicotyledons are abundant in both. The difference in the species may be accounted for on geographical and topographical grounds, as one may now select two places not widely separated at which quite different plants are growing.

There remain 8 species of dicotyledons occurring in the typical Maryland beds. Of these *Proteœphyllum oblongifolium*, *Quercophyllum tenuinerve* ?, the three Rogersias, and *Saliciphyllum ellipticum* are all found in the Langdon or Arlington beds. These certainly argue for an age for these beds not lower than the Rappahannock of Virginia.

The only source that remains from which evidence of a lower position for the Maryland beds can be looked for is the new species found in them. If these beds are really Jurassic and the bulk of the flora consists of Rap-

pahannock species that originated in them and persisted through the Potomac period in Virginia, the new forms not yet found in the Virginia Potomac ought to have a distinctly Jurassic facies and be comparable to those of the other well-known Jurassic floras of the globe. The following are the 12 new species occurring in the Maryland beds exclusive of Rosiers Bluff:

Abietites marylandicus, Vinegar Hill, 2 specimens.
Adiantites parvifolius, Federal Hill, 1 specimen.
Celastrophyllum ? marylandicum, Federal Hill, 1 specimen.
Cladophlebis acuta angustifolia, Arlington, 115 specimens.
Ginkgo ? acetaria, Vinegar Hill, 1 specimen.
Pinites Leei, Union Tunnel, Baltimore, 1 specimen.
Plantaginopsis marylandica, Federal Hill, 5 specimens.
Proteæphyllum Uhleri, Federal Hill, 1 specimen.
Rogersia angustifolia parva, Langdon, 5 specimens.
Selaginella marylandica, Vinegar Hill, 1 specimen.
Thinnfeldia marylandica, Arlington, 16 specimens.
Williamsonia ? Bibbinsi, Vinegar Hill, 1 specimen.

It will be seen that, of these 12 new species, 4 are dicotyledons, and 1 of these, *Rogersia angustifolia parva*, comes from typical Arundel strata. Eight of them are from Vinegar Hill and Federal Hill, which are probably on a higher horizon and have not been regarded as probably Jurassic. These, therefore, have really no proper bearing on the question at issue. The *Pinites Leei* from Union tunnel may also be excluded from the discussion; as I have stated, it has so modern an aspect as to suggest that the clay in which it was found may be of Pleistocene age. The only plants, therefore, which have any importance for the claim that the iron-ore beds may be Jurassic are *Cladophlebis acuta angustifolia* and *Thinnfeldia marylandica*. Both these are abundant in the Arlington beds and are confined to them. The first is simply a narrow-leaved form of the type *Cladophlebis acuta*, and might denote a lower or a higher horizon according to whether the leaves were tending to become wider or narrower, which can not be known. It can not, therefore, be said to argue either way. As regards the second, there are 3 other species of Thinnfeldia in the Older Potomac, one of which, *T. variabilis*, runs up into the Brooke beds. The genus Thinnfeldia is properly Older Mesozoic, but plants have been referred to it from the

Rhetic to the Middle Cretaceous. Its relations to Sagenopteris on the one hand and Cladophlebis on the other are imperfectly defined. But at all events, whatever its occurrence in the Maryland beds may argue for their age, its occurrence in the Virginia beds must argue the same for them, so that this can not be regarded as evidence that the former are older than the latter. In fact the evidence throughout is all in favor of the practical identity of the age of the Older Potomac in both States.

One of the unexpected results of this study of the Potomac formation in Maryland is the determination of most of the abundant cones found in so many of the beds as belonging to the extinct genus Athrotaxopsis. This genus was established by Professor Fontaine for twigs, leaves, and cones of the Potomac of Virginia that approach most nearly to those of the living Tasmanian genus Athrotaxis of Don. This is placed by Eichler, in the *Natürlichen Pflanzenfamilien* of Engler and Prantl, next to the genus Sequoia and between this and Cryptomeria. The cones collected by Mr. Hatcher in the iron shaft near Muirkirk associated with the dinosaurian bones of which so much has been said, are all referred to this genus, and similar cones occur at Langdon, Riverdale, Contee, Arlington, the Howard Brown estate, Hobbs's iron mine, Tip Top, Soper Hall, and Poplar Point, showing that this was the predominant conifer of the region at the time these beds were laid down. Twigs of the same genus also occur at a number of localities, and two species, *Athrotaxopsis expansa* and *A. tenuicaulis* are represented.

Associated with these cones at many places, notably in the Muirkirk beds, where the largest number were found, as well as the dinosaurs, are great quantities of silicified wood. Unfortunately this wood has been studied only at a few localities and not at any of those where the cones occur, but wherever it has been studied it has been found to belong to the genus Cupressinoxylon. The structure of the wood of this genus, however, is essentially sequoian, and I had long regarded the Potomac forests as practically those of Sequoia. It is indeed true that Professor Fontaine recognizes the genus Sequoia in several of the Maryland beds, and he refers most of the cones found at Soper Hall, which are larger than those of Muirkirk, but otherwise very similar to them, to *S. ambigua* Heer. It would seem, therefore, that the great sequoian forests of

Potomac time in Maryland, the District of Columbia, and Virginia consisted of several types, perhaps generically distinct, but still practically sequoian. These forests, as the present work clearly shows, extended entirely across the continent and probably covered the whole of North America. But for some reason the sequoian type of structure lacked the elements necessary to resist the changes taking place in the environment, especially the competition of the more modern coniferous vegetation that came on in later Cretaceous and Tertiary time, and it was gradually crowded out of existence over most of this great area where it had so long been dominant, and was finally stranded in two narrow belts in California, along the Coast Range and the Sierra Nevada, respectively, where the last survivors of the genus Sequoia still persist in the only two living species, *S. sempervirens* (Lambert) Endlicher, the redwood, and *S. Washingtoniana* (Winslow) Sudworth, the mammoth tree.

COLUMNAR SECTION OF THE POTOMAC FORMATION.

Taking into consideration all the facts presented in Professor Fontaine's report as condensed in the table, together with all that was known of the Potomac formation down to the present time, it is possible to recast the section of the entire formation. This, then, will assume something like the following form:

In the geological column published in my paper on the Potomac formation[a] I gave the entire formation a thickness of 1,175 feet. If we now give it a thickness of 1,200 feet, which it probably has, and make the Raritan, as was done then, 500 feet, we have for the Older Potomac a total thickness in Maryland of 750 feet, of which the upper 225 feet are not represented in Virginia. This is the portion to which I then assigned the iron ore, under the prevailing impression that all the Maryland beds were higher than any of the Older Potomac in Virginia. We now know that practically all the iron ore occurs on the same horizon as the Rappahannock of Virginia, viz, in the Arundel of Clark and Bibbins. These beds in Maryland overlying the iron-ore clays and assigned to the Patapsco consist of alternating clays and sands and form a more or less gradual transition into the overlying Raritan beds. Except at Rosiers

[a] Fifteenth Ann. Rept. U. S. Geol. Surv., 1893–94, p. 339.

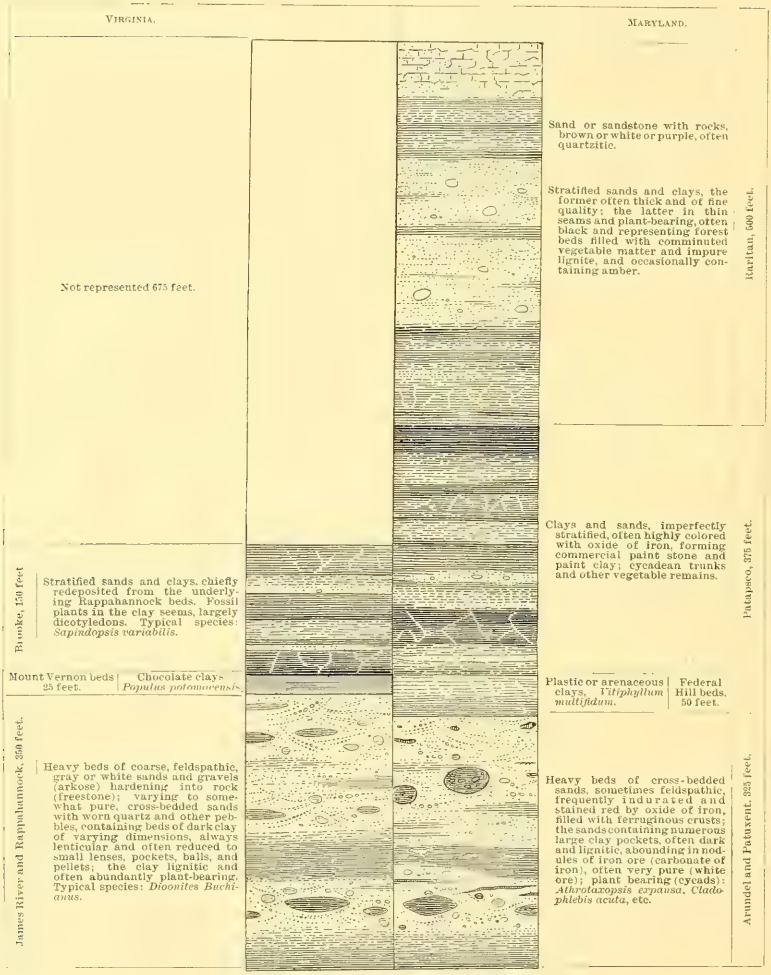

FIG. 11.—Columnar section of the Potomac formation.

Bluff none of them yield a characteristic Brooke flora, and they are for the most part, so far as at present known, practically barren. I include the Federal Hill beds in the Patapsco, making the upper part the homologue of the Mount Vernon beds, but as only 25 feet of the latter have been measured, while at Federal Hill we have an actual section of 46 feet,[a] it is assumed that these beds extend some 25 feet lower. Giving the Virginia beds the same thickness as before, the Patuxent with its included Arundel occupy 325 feet, or 25 feet less than the combined James River and Rappahannock, assuming the base of the formation to be the same in both States.

As thus presented, the evidence derived from the stratigraphy of the Potomac formation harmonizes perfectly with that derived from the fossil plants, and the correlation of the formation in Virginia and Maryland is complete.

[a] See The Potomac formation: Fifteenth Ann. Rept. U. S. Geol. Surv., 1895, p. 331.

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